Development of an Epidemiological Index for Primary Anterior Teeth Affected by Erosion and Prevalence of Dental Erosion in Pre-school Saudi Children

Manal Al-Malik

A thesis submitted for the degree of Doctor of Philosophy University College London

Department of
Transcultural Oral Health
Eastman Dental Institute
2000

DEDICATION

WITH MUCH LOVE AND ADMIRATION

I DEDICATE MY WORK

TO MY HUSBAND AND TWO PARENTS

ABSTRACT

Erosion affects both dentitions but has proved difficult to measure. It has been thought to affect children who are less susceptible to caries but previous studies have been confined to countries where caries prevalence is low.

The aims of this study were first, to develop and then investigate the validity of an index to measure erosion in primary teeth. Secondly, to determine the prevalence of erosion in primary incisors amongst kindergarten children in Jeddah and its relationship to caries in the same children. Thirdly, to investigate determinants of erosion and caries in the sample.

A sample of 41 exfoliated and extracted primary anterior teeth were scored visually and photographically and scores related to appearance on section. Erosion, caries and rampant caries were then measured in a sample of 987 children. The survey included a questionnaire to parents.

Scores used in the index through visual inspection and photographs were related consistently to appearance of lost enamel on section. Sensitivity was 0.94 and specificity was 1.0. Kappa values for repeat assessments all exceeded 0.77.

Thirty one percent of the children in the survey had evidence of erosion on clinical examination. For 186 this was confined to enamel but for 123 it involved dentine and/or pulp. Amongst the 727 who had readable photographs, 30% had erosion on photographic and 36% on clinical examination. Agreement was seen between the two methods for 93% of the surfaces included.

Caries affected 720 (73%) of the children and rampant caries 336 (34%). More children with caries, (excluding rampant caries), had erosion (36%) than children who were caries free (27%).

Vitamin C supplements, frequent use of carbonated drinks and the consumption of fruit syrup from a feeding bottle at bed/nap time as a baby were all related to erosion. These drinks were also related to caries but were part of a larger number of significant factors including socio-demographic measures and oral hygiene practices.

TABLE OF CONTENTS

LIST OF FIGURES

Page

Figures

LIST OF TABLES

CHAPTER ONE

INTRODUCTION AND AIMS OF THE STUDY

1. INTRODUCTION

Dental caries and periodontal disease continue to play a dominant role in thinking and practice in oral health throughout the world. Erosion, or pathological tooth tissue loss occurring as a direct result of chemical action on the tooth surface, has emerged more recently as a problem affecting children and adolescents. Erosion is caused by acids. These may include gastric acid, resulting from regurgitation, or more often acid derived from the diet. The type of acid, and the food or drink which contains it are believed to be important in determining its effects. Subjects may also vary in their susceptibility to erosion; saliva is believed to have an important influence on the occurrence and severity of erosion.

Epidemiological measurement of erosion has relied heavily on subjective judgement of, for example, relatively minor degrees of loss of enamel surface contour and measurement has proved difficult in consequence. In addition, it has not always been clear whether loss of enamel has been a result of erosion alone adding to the difficulty in distinction. More than one index has been introduced, but none has proved wholly satisfactory.

Investigations of erosion have been largely confined to European countries, where caries has declined with time. From results it has been thought that erosion is more common amongst those who are less susceptible to caries. There has however been much less consideration of erosion in other countries and cultures, particularly developing countries where caries may be more prevalent. In these countries dietary

patterns may be very different but consumption of acidic foods and drinks may be no less.

Parts of the Middle East exemplify many developing countries in being rich in natural resources but until relatively recently, lacking the technological and business infrastructures that facilitate economic progress. The exploitation of oil fields in the Middle East has resulted in many countries in the region undergoing a period of extremely rapid modernisation. This is particularly true of countries of the Arabian Gulf. Within a period of less than 100 years, the population of the region has changed from one consisting largely of nomadic tribes to one living mainly in large cities and townships. There have been major changes in socio-economic status, exemplified by much greater personal affluence for much of the population (Saudi Arabia now has the highest income per capita in the world), but living standards in some groups, such as rural migrants, have remained low. The great resources of countries such as Saudi Arabia have allowed extensive development of education and health care. Education is now much more widely available to everyone. Studies have shown dramatic improvements in health, with increased life expectancy and reduced infant mortality but diseases characteristic of developed countries, such as cancer and coronary heart disease are now increasing. Typically, child health and survival are now related to social factors that include parental education and housing quality.

Little was known about oral health in Saudi Arabia prior to 1990 but more recent studies have demonstrated that caries represents a particular problem amongst children (Al-Shammery 1990, Al-Mohammedi 1995). A high prevalence of enamel opacities has also been reported. The latter were thought to relate particularly to malnutrition during

the period of tooth formation suggesting that nutritional status in at least some children in the area still lags behind that seen in more fully developed countries.

The Kingdom of Saudi Arabia occupies the largest part of the Arabian Peninsula, covering an area of 2,240,000 square kilometres (864,900 square miles). It has a population of 18.8 million, 70% of whom are Saudi nationals. As in many developing countries, a high proportion of the population are under 15 years of age. The country is divided into a series of provinces or governorates, the largest of which are the Central, Western and Eastern Provinces. Each has a capital and contains a number of towns and villages. The largest city in the Western Province, Jeddah, lies on the Red Sea Coast and has a population of approximately 2 million. The climate of Saudi Arabia includes a very high day time temperature for many months of the year and scant, unreliable rainfall. The Western coast, including Jeddah, is also oppressively humid.

Health Services in the Kingdom are provided through the Ministry of Health, through other government organisations and through the private sector but although there is greater provision in the cities, access to care is sometimes limited in other areas.

Traditional dietary habits and practices have continued but foods and drinks typical of westernised diets are cheap and readily available, particularly in cities such as Jeddah, so that children may well be at similar risk of both caries and erosion.

2. AIMS OF THE STUDY

The aims of the present study are therefore:

1. Using a sample of primary teeth
   a) to investigate the reproducibility of an index of erosion and
   b) to relate findings on visual examination and using photographs, to appearance on histological section of the teeth.

2. To use the index and methods tested in 1. above
   a) to determine the prevalence of erosion in a sample of children attending kindergarten schools in Jeddah, Saudi Arabia and
   b) to relate the prevalence of erosion to that of caries and rampant caries in the same sample of children.

The null hypothesis to be tested is that there is no relationship between caries and erosion in this group of children.

3. Through a questionnaire, to the parents of children included in the sample used in 2 above, to investigate the following determinants and their relationship to erosion and caries:
   a) Social class and education of the child's mother.
   b) Dietary practices including infant feeding habits, use of drinks in infant feeding bottles, current dietary habits, use of iron and Vitamin C supplements.
   c) Oral hygiene practices in terms of age at starting tooth brushing, frequency of brushing and supervision and help with brushing.

The null hypothesis to be tested is, in the case of each group of factors, that the factors are not related to erosion.

CHAPTER TWO

LITERATURE REVIEW

1. Introduction

Erosion represents one of three mechanisms that may result in the type of irreversible loss of dental hard tissue that has been defined more broadly as 'tooth wear'. The other two are both physical and include contact between opposing and adjacent teeth during function and parafunction and object to tooth contact. Some degree of wear is physiological but may be regarded as pathological if the teeth become so worn that they do not function effectively or if it seriously mars their appearance before loss through other causes or the patient dies (Smith &Knight1984 a).

Erosion has been defined as a superficial loss of dental hard tissues by a chemical process that does not involve bacteria (Pindborg 1970). It is not directly associated with mechanical or traumatic factors or with dental caries but may be accelerated by the effects of these.

Erosion therefore differs from attrition, which is defined as the physiologic wearing away of a tooth as a result of tooth-to-tooth contact. A certain amount of attrition is physiologic; however, it becomes pathological when it is excessively destructive.

It also differs from Abrasion, which is caused by an object-to-tooth contact such as the effect of toothbrushes on exposed cervical dentine.

Localised loss of tooth tissue occurring as caries, which is believed to be chemical attack mediated through bacterial action, is excluded by these definitions.

1.1 Clinical Features of Erosion

Erosion may affect either primary or permanent teeth. It may demonstrate symptoms and/or signs or may represent an incidental finding on examination. Diagnostic features have most often been described in permanent teeth but many may also be seen in primary teeth.

Erosion, attrition, and abrasion most often occur simultaneously, although one of the three may be most prominent from time to time and from case to case. The signs of erosion are readily overlooked, particularly in cases of attrition (Lewis & Smith 1973).

As early as 1947, tooth wear caused by acid solutions was described as being a more or less common occurrence. Erosion in permanent teeth has since been consistently reported as resulting in symptoms of hypersensitivity to thermal changes and hygroscopic substances. Findings on examination include characteristic patterns of tooth tissue loss and presence of restorations raised above surrounding tooth surfaces. The dietary history offered has also been thought to be a clinical feature of erosion.

a) Hypersensitivity to thermal changes and hygroscopic substances

Hypersensitivity to thermal changes and hygroscopic substances, which may be persistent, has been described as characteristic of erosion. This may be a major complaint and is often the patient's primary reason for seeking the help of the dentist (Stafne & Lovestedt 1947, Smith &Knight 1984 a).

b) Pattern of tooth tissue loss

The pattern of loss of tooth tissue has been described as diagnostic of erosion. This includes the pattern within the dentition and the nature of erosive lesions affecting a given tooth or tooth surfaces.

Theoretically, erosion may affect any tooth or tooth surface but it does appear to show distinct patterns. In the dentition as a whole, erosion may affect the maxillary arch to a greater extent than the mandibular (Johnson & Sivers 1987). Maxillary anterior teeth are more often affected but in severe cases mandibular posterior occlusal and lingual surfaces may be involved. Erosion has been suggested as particularly affecting palatal or lingual surfaces (Johnson & Sivers 1987). However, this may not always be the case. It has been suggested that erosion arising from extrinsic causes usually affect the palatal and/or buccal surfaces of upper anterior teeth. A somewhat different distribution of erosion is believed to occur when the main aetiological factor is gastric reflux or regurgitation. In these cases, the palatal aspects of the upper incisors and the occlusal and buccal aspects of the lower posterior teeth are preferentially affected, a condition called 'perimolysis' (Bartlett & Smith 1994). In cases resulting from voluntary and prepared vomiting, the pattern of attack is thought to be a result of the tongue directing gastric contents forward while the lateral spread of the tongue protects the lower teeth (Hellstrom 1977, Stege et al 1982, Bartlett & Smith 1994).

Mild erosion may be well localised but in severe cases, enamel loss may extend over the whole surface (Eccles 1974). The early stages of erosion result in loss of normal enamel surface contour, including loss of developmental ridges on the enamel, and a smooth glazed enamel surfaces. The absence of stain and stain lines is thought to be

characteristic of active erosion and may produce an appearance of a recent dental prophylaxis (Stafne & Lovestedt 1947).

As it continues, erosion results in enamel defects with rounded margins (Stafne & Lovestedt 1947). The creation of concavities primarily in the cervical region of the labial (or sometimes lingual surfaces), is thought to be characteristic. These have an enamel surface whose breadth greatly exceeds their depth, and thus differ from cervical lesions resulting from abrasion (Eccles 1974). The appearance of depressions on the cusps of posterior teeth (cupping), and on the incisal edges of anterior teeth producing either the same effect or a grooved appearance, is also thought to be typical of erosion. The process may also result in notched cervical surfaces (Eccles 1974).

Increased translucency and chipping of the incisal edges is one of the features of erosion. More severe erosion may be sufficient to prevent normal contacts between incisal or occlusal contacts in any mandibular excursion (Smith &Knight1984 a). Permanent incisor teeth may be reduced in length to the extent that length is out of proportion to tooth width (Smith &Knight1984 a).

Erosion is often confined to enamel but may be sufficiently severe to affect dentine on buccal or lingual surfaces, secondary dentine or even result in pulp exposure. Severe erosion may result in loss of pulp vitality (Smith & Knight1984 a). Involved dentine may show a polished surface although some teeth may have a dull, matted appearance. This is believed to be associated with active erosion. A common finding, when the erosion has affected the palatal surfaces of maxillary anterior teeth, is a central area of exposed dentine surrounded by a border of unaffected enamel at the gingival margin (Bishop 1997).

c) Restorations raised above the level of surrounding tooth tissue

The presence of restorations which project above the surfaces of the tooth has been regarded as an important clinical feature of erosion (Stafne & Lovestedt 1947). Amalgam fillings may also be unusually clean in appearance, presumably due to the absence of normal corrosion products. This has been thought to be of particular diagnostic value (Eccles 1974).

d) History

A careful history is believed to aid in differentiating between attrition, abrasion, and erosion with the history of those with erosion showing evidence of high dietary intake of acidic foods or drinks for example, or of the likelihood of recurrent vomiting or regurgitation (Smith &Knight1984 b).

Sensitivity, 'cupping' and projection of restorations above the adjacent tooth surfaces are thought to be the most characteristic clinical features of erosion.

1.2 Differential Diagnosis of Erosive Lesions

Because tooth wear may be a consequence of a combination of erosion, attrition and abrasion, it is not always possible to distinguish the three, particularly in their early stages. There, are, nevertheless, some points of distinction and it has been suggested that the three conditions may be differentiated not only by the history, but also by the clinical appearance (site and shape of lesions), age and the sex of affected subjects. Whilst erosion may primarily affect palatal or labial surfaces of upper anterior teeth, attrition occurs more often on incisal, occlusal and lingual surfaces of upper anterior and/or labial surfaces of lower anterior teeth as a result of tooth-to-tooth contact. Tongue grooving and scarring of buccal mucosa have also been described as concurrent features in attrition in older subjects with long standing wear.

The first clinical manifestation of *attrition* may be the appearance of a small polished facet on a cusp tip or ridge or a slight flattening of an incisal edge with the lesion determined by the contact and movement of the opposing tooth. Tooth surfaces worn by attrition are hard, smooth and shiny, and if dentine is exposed, a yellowish-brown discoloration is often present. As a result of secondary dentine formation this gradual loss of enamel and dentine does not usually result in tooth sensitivity. As wear progresses there is a reduction of cuspal height and inclination. In attrition wear usually occurs in a generalised fashion. The exposed dentine ultimately wears at the same rate as the surrounding enamel (Johnson & Sivers 1987, Bishop 1997).

Abrasion is most often a result of incorrect tooth brushing techniques. It may also result in trauma to the soft tissues and lead to gingival recession with root surface exposure.

Abrasion through inappropriate brushing results in wedged-shaped cervical defects with sharp margins and a hard smooth surface. They are most often described in the permanent dentition on the buccal (or labial) and cervical aspects of the teeth (Asher & Read 1987), and are likely to be more severe on one side than on the other (Nunn et al 1996).

In relation to age, attrition has been reported in older people, erosion more often affecting younger individuals, while abrasion may occur at any age. With respect to gender, attrition and abrasion tend to be more prevalent in males, whilst erosion tends to be slightly more common in females (Rugg Gunn 1993).

2. Pathogenesis and Aetiology of Erosion

2.1 Pathogenesis of Erosion

Tooth wear is rarely caused by a single factor acting alone. Pathogenesis may therefore not always be distinct. It has, for example, been shown that dental hard tissue softened by erosion is more susceptible to attrition (Sorvari et al 1996).

Perhaps partly because it does not occur in isolation from other processes, the pathogenesis of dental erosion is not yet completely understood. The condition is essentially a consequence of acidic solutions coming into contact with the teeth, with one of the main modifying factors being the flow of saliva. Because the critical pH for demineralisation of dental enamel is approximately 5.5, any solution with a lower pH value has potential to cause erosion, particularly if the contact is of long duration, and/or is repeated over time. Whatever the cause (intrinsic or extrinsic acid), the gross pathology includes superficial demineralisation of dental hard tissue, primarily by

dissolution of the apatite crystal. This may lead to severe or total destruction of the teeth, depending on the strength of the agent, in terms of low pH, the level of calcium, and phosphorus present in the surrounding medium, its chelating (Ca binding) properties, and the frequency of erosive attacks (Meurman & ten Cate 1996).

2.1.1 Erosion of enamel

Ultrastructural in vitro studies have shown that erosive lesions are seen in prismatic enamel as characteristic demineralisation patterns where either the prism cores or interprismatic areas dissolve, leading to a honeycomb structure. The lesion first develops in the prism sheath areas, followed by dissolution of prism cores with more prolonged acidic challenge (Meurman & Frank 1991a,b). Eventually, the interprismatic areas also become affected. Depending on the chemical composition of the outer enamel layer (in particular the fluoride content), erosive patterns vary in a similar way as reported for acid etching of enamel (Silverstone et al 1975). In vitro, the lower the pH the more erosive is the solution, but titratable acidity and chelating properties may also greatly modify the rate of erosion (Rytomaa et al 1988).

In aprismatic enamel the pattern of dissolution is more irregular, and this type of structure is probably less liable to erosive destruction than prismatic enamel. In a study of this phenomenon, the authors observed areas of distinctly eroded enamel adjacent to less affected areas when specimens with aprismatic enamel were subjected to experimental erosion (Meurman & Frank 1991a).

2.1.2 Erosion in primary teeth

Primary teeth, which have aprismatic enamel at their surface, and a chemical composition differing somewhat from that of permanent teeth, may be anticipated to be more resistant to erosion. Nevertheless this pathology has been shown to affect both dentitions (Smith and Shaw 1987, Asher and Read 1987).

In one recent study of extracted teeth, primary teeth were used to emphasise the occurrence of this pathology in younger children. Morphological analysis of affected enamel was carried out using stereomicroscopy and scanning electron microscopy (SEM), after experimental exposure to drinks of low pH for different time periods. Stereomicroscopy showed loss of gloss and an alteration in normal colour of enamel, with irregular loss of dental hard tissue to variable degrees. Such a loss became more serious as the time of incubation increased. Different degrees of solubilization of enamel prisms were demonstrated by SEM, affecting initially the sheaths and the heads of prisms and later their tails. Areas of erosion increased directly in proportion to time of incubation (Grando et al 1996).

2.1.3 Erosion in dentine

Experimental erosion in dentine caused by different acidic solutions has been investigated with scanning electron microscopy (SEM). In dentine the first area to be affected is the peritubular dentine. With lesion progression, the dentinal tubules become enlarged but finally disruption is seen also in the intertubular areas, resulting in rough and porous surfaces. If the erosion process is rapid, increased sensitivity of the teeth may be a presenting symptom, because the acid causing erosion can expose inner

dentine structures to outer stimuli by significant enlargement of the dentinal tubules. However, in cases with slower progression, the patient may remain without symptoms even though the whole dentition may become severely damaged (Meurman et al 1991). It must be emphasised that in the majority of experimental studies, no protective factors (such as saliva or fluoride) had been taken into account.

2.2 Aetiology of Dental Erosion

Erosion has been regarded as multifactorial in aetiology. Both intrinsic and extrinsic sources of acid are potentially able to contribute to loss of tooth tissue. Whilst the acid represents the cause of erosion, the process may be affected by other determinants such as lifestyle and oral hygiene practices. Extrinsic erosion is the result of exogenous acids derived from the diet for example. Intrinsic erosion is the result of endogenous acid, usually gastric acid, contacting the teeth during recurrent vomiting, regurgitation or gastric reflux. Idiopathic erosion is the result of acids of unknown origin. In addition to direct causation, people also vary greatly in their susceptibility to apparently similar challenges. This may relate to such factors as differences in tooth structure or in salivary protection factors.

In young people as in adult subjects erosion has been related to both extrinsic factors, especially dietary, and intrinsic factors including gastric regurgitation and parafunctional activity.

2.2.1 Extrinsic Factors

There are many possible extrinsic sources of acids that may contribute to dental erosion. These may be considered as environmental, or dietary in origin or may be in the form of supplements or medications. It is unlikely that any one aetiological factor operates in total isolation from all others. Tooth wear, of which erosion forms a part, is a cumulative lifetime process, which is to a large extent irreversible.

I) Environmental Factors

Dietary factors constitute much the largest direct environmental effect on erosion but others include occupational and recreational exposure to acids.

Industrial environmental effects have been shown to be the primary aetiological factor in several clinical surveys in Scandinavia (Tuominen & Tuominen 1991,Tuominen & Tuominen 1992, Peterson & Gormsen 1991).

Occupational environmental factors are mainly limited to those directly exposed to acid fumes or aerosols. In the past dynamite factory workers were recognized to be at especially high risk (Miller 1907). Others at risk include battery factory workers, galvanizing factory workers, those exposed to etching and cleaning processes involving acids, and fertilizer factory workers. Laboratory workers, and professional wine tasters may also be at risk. Although most industries in developed countries now follow safeguards to protect workers, environmental and occupational hazards may be an emerging problem in developing countries.

Recreational exposure has been seen in competitive swimmers as a consequence of swimming in inadequately treated gas-chlorinated pools. This chlorination method results in formation of hydrochloric acid and neutralization and buffering is needed to maintain the neutral pH range of 7.2 - 8.0. Water treated in this way requires monitoring to ensure treatment is adequate (Savad 1982, Centerwall et al 1986).

With the exception of frequent use of chlorinated swimming pools, most environmental and occupational hazards are not thought to affect children.

II) Dietary Factors

Dietary factors have received the most attention and are thought likely to affect the broadest segment of the population. Their role has been recognized for many years and they are probably the most important cause of dental erosion (Holloway et al 1958, Rugg-Gunn 1986).

Most low pH foods and drinks are believed to have the potential to cause dental erosion in the human mouth. It appears that, as a rule, foods and drinks with a pH above 4.5 have a low potential to cause dental erosion. The total acid level (titratable acid) of acidic dietary substances is considered more important than their pH, because it will determine the actual H^+ available to interact with the tooth surface. Those containing acids with calcium-chelating properties, such as citrate, may carry added potential to cause tooth damage at higher pH levels, although it is unclear whether these mechanisms are operational in the mouth (Zero 1996). Citric acid was found to be one of the stronger organic acids and forms soluble, poorly ionized complexes with calcium (Zero 1996).

As well as acidity other constituents of food and beverages will also have a modifying effect, including the calcium, phosphate and fluoride concentration, the acid type, and physical and chemical properties that may affect the clearance rate from the mouth. It is not yet possible to assign relative degrees of risk to different dietary substances except in general categories, because of the many human, biological and behavioural modifying factors. For example some beverages, such as soft drinks, may present a higher degree of risk of causing erosion than can be estimated from their chemical properties alone, because of their pattern of frequent consumption.

Some of the most common dietary causes of dental erosion are listed in Table 2.1, modified from a previous review by Rugg-Gunn (1993).

Table 2.1 **Common dietary causes of dental erosion**

(modified from Rugg-Gunn 1993)

Fruit-flavoured infant drinks
Liquid oral medicines and supplements, especially iron tonics
Vitamin C supplements as liquids and soluble tablets
Soluble Aspirin tablets
Carbonated drinks including low calorie varieties, sparkling water and 'sports' drinks
Fruit juices
Citrus fruits (e.g lemons, orange, grapefruits)
Other fruit (eg apples)
Acid sweets (eg acid drops, mints, sour balls)
Seasonings and condiments (eg Vinegar, Pickles, pickled onions)
Yoghurt

Amongst dietary items, acidic drinks, thought to be a major cause of erosion, are available to all age groups of children. Fruit juices for example are widely consumed by infants and many have been shown to have pH values well below the critical pH for the dissolution of enamel (Smith & Shaw 1987). Drinks of this type may be given to infants in feeding bottles. The highly acidic nature and high sugar content of the drink together

with the prolonged exposure of the teeth may constitute a risk for erosive tooth tissue loss as well as dental caries. The introduction of cola-type drinks, which first became popular at the time of the Second World War, and greater canning of fruit juices and fruit based drinks may have contributed to the very great rise in consumption of soft drinks. These drinks are believed to pose a considerable risk of erosion (Rugg-Gunn 1986).

A list of potentially erosive drinks, their pH and titratable acidity is given in Table 2.2 (Shaw 1998).

Table 2.2 **Erosive potential of drinks compared to their pH and titratable acidity** (Shaw 1998)

Drink	Relative titratable acidity	pH	Erosive potential
Cola	0.7	2.5	Medium
Schweppes	2.6	2.6	Medium
Diet Cola	0.5	2.9	Medium
Carbonated orange drink	2.0	2.9	Medium
Grapefruit juice	9.3	3.2	High
Apple juice	4.5	3.3	High
Red wine, Claret	3.3	3.4	Medium
White wine-Chardonnay	2.2	3.7	Medium
Orange juice	4.8	3.8	High
Beer-Bitter	0.6	3.9	Low
Beer-large	0.5	4.4	Low
Sparkling water	0.1	5.3	Low

The evidence linking acidic foods and drinks with erosion has been drawn from clinical studies, animal studies, and in vitro investigations.

A) Clinical Studies Implicating Dietary Factors in Erosion

Clinical studies providing evidence of the role of dietary factors in erosion may be considered as falling under three headings:

1. Case Reports
2. Epidemiological Studies
3. Interventional Studies

1. Case Reports

Much of the clinical evidence linking specific dietary factors to dental erosion has appeared in the form of anecdotal case reports or reviews of a series of cases.

In adults reports have described cases of erosion involving citrus fruits in a variety of differing forms, either drinking lemon juice, eating or sucking lemons or eating grapefruits. The site of erosion has varied according to the way in which the fruit or fruit juice was taken, such as relating the erosion of the labial surfaces of maxillary incisor to sucking of fresh lime or lemon halves (Allan 1967, Fuller & Johnson1977, Reuter 1978).

In case reports, erosion has also been linked to cola drinks, to lemon tea drink at night, and to high fruit intake (Lewis & Smith 1973, Eccles & Jenkins1974).

In children also excessive consumption of fruit flavoured drinks (large quantity of low pH soft drinks) was reported to have caused dental erosion in a review of 12 cases of 9-

15 years old children attending the Manchester dental hospital. The children had all drunk between one and three 725 ml bottles of the same brand of fruit flavoured drink per week and never drank coffee, tea, milk, or water. In all cases the palatal surface of maxillary incisors were the most commonly affected, followed by the occlusal surfaces of the mandibular molars (Asher & Read 1987).

Fruit juices intended for consumption by infants (termed pure fruit juices for babies), are primarily concentrated fruit juices with added vitamin C. In a case report of extensive erosion in a 2 year old girl, investigation into her dietary habits revealed prolonged use of baby fruit juice at night time in a feeding bottle used as a comforter (Smith & Shaw 1987).

Not all case reports have confirmed the role of dietary factors in every instance of erosion. In a review of cases of erosion attending Cardiff dental hospital it was reported that only 7 of 19 cases included gave a history of possible dietary factors (such as cola-type drinks, fruit drinks, fruits, and vinegar on food). Seven had a history of regurgitation or heartburn but in 5 cases no causes could be identified (Eccles 1982).

2. Epidemiological Studies

Epidemiological observational studies have also provided information on the relationship between diet and dental erosion. Fifty years ago, a marked increase in the consumption of lemon juice was reported to have caused an increase in the destruction of teeth. However, it was reported that whilst some individuals drinking lemon juice daily for therapeutic reasons showed a marked degree of erosion after only 3 months of use, others showed less erosion after more than a year of use (Stafne & Lovestedt 1947).

In more recent studies associations have been found between erosion and consuming citrus fruits more than twice per day (Linkosalo & Markkanen 1985, Jarvinen et al 1991, Lussi et al 1991), fruit juices (Lussi et al 1991), consuming vinegar & vinegar conserves (Linkosalo & Markkanen 1985, Jarvinen et al 1991), and acidic berries (Linkosalo & Markkanen 1985). Having soft drinks daily and sports drinks once a week or more have also been associated with dental erosion (Jarvinen et al 1991).

All of these studies were confined to adults, but a more recent investigation was carried out in a group of 4 -16 years old children attending a university dental hospital. Eighty per cent showed evidence of erosion although this was mostly in the mild category. An increase in the mean frequency of consumption of fruit drinks, carbonated beverages and fruit juices was associated with an increase in severity and bedtime consumption of fruit juices was especially strongly associated with the most severe cases (Millward et al 1994 b).

3. Interventional Studies

There have been two clinical trials involving erosion. In the first, the effect of daily ingestion of different amount of acidic beverages on the maxillary anterior teeth of a group of dental students and hygiene students was tested. The first appearance of alteration of the enamel surface occurred between the 4^{th} and the 6^{th} week of the study (Thomas, 1957).

In the second study, a group of 6-7 year old children drank 100ml of orange beverage (pH=3.5) on school days daily for 12-18 months. Their exfoliated primary teeth were compared with teeth from children who did not receive any beverage at school, and showed slight signs of demineralization (Stabholz et al 1983).

These studies might now be regarded as unethical in actively promoting consumption of potentially harmful agents in human subjects.

Other studies have attempted to evaluate the erosive potential of beverages by less direct methods. Methods employed have included use of an in situ model to study not only the erosive effect of an acidic carbonated beverage but also the reparative effect of saliva and dairy products in the human mouth (Gedalia et al 1991 a & b, West et al 1998). A one hour exposure to an acidic beverage caused softening in the enamel surface of tooth sections. In contrast, a one hour exposure to cow's milk and a 5 minutes chewing period with cheddar cheese both resulted in statistically significant increases in surface hardness of acid softened enamel. A one hour exposure to saliva in the mouth also significantly rehardened the acid-softened enamel, presumably through rehardening as a result of organic and mineral material being deposited on the enamel surface. Exposure to stimulated saliva for a much more limited period of 5 minutes did not have the same effect (Gedalia et al 1991 a & b).

B) Animal Studies

Animal models, particularly rats, have been widely used to evaluate the erosive effect of dietary items, but only general conclusions can be derived from these because of the difference in oral physiology between rats and humans.

Ingestion of dilute solutions of hydrochloric and lactic acids was found to be very destructive to enamel and dentine of rats (McClure 1943).

The erosive potential of soft drinks, including fruit squashes and cordials, 'sport drinks' and carbonated beverages sold in the United Kingdom, have also been demonstrated in several animal studies over the last 40 years (Holloway et al 1958, Stephan, 1966, Sorvari, 1989).

Foods such as apples, orange slices, lemon slices, grapes and dried apricots have also been shown to produce dental erosion in experimental animals (Stephan1966).

Both the titratable acidity of the beverage and saliva buffering capacity have been demonstrated to be important factors in dental erosion through animal models (Holloway et al 1958). The addition of fluoride to erosive solutions has also been shown to have a protective effect (Sorvari 1989).

In several of these studies a marked variation was noted in the degree and pattern of dental erosion among rats receiving the same treatment, which was attributed to differences in susceptibility to erosion.

C) In Vitro Investigations

In vitro studies of dental erosive properties of acidic foods and drinks have a long history and have again become popular (Miller 1907, West & Judy 1938, Imfeld 1983, Rytomaa et al 1988, Duggal & Curzon 1989, Lussi et al 1993, Grobler et al 1994).

Studies have included simple investigations, such as one in which a tooth was placed in grape juice for a 4 week period (Miller 1907), studies using bovine enamel (Rytomaa et al 1988) and intra-oral telemetry systems (Imfeld 1983).

Investigations have shown the erosive potential of cola and fruit drinks, of sports drinks and of carbonated drinks (Miller 1907, West & Judy 1938, Imfeld 1983, Rytomaa et al

1988, Duggal & Curzon 1989, Meurman et al 1990, Meurman and Frank 1991 a, Lussi et al 1993, Grobler et al 1994).

As with animal studies, only general conclusions can be reached from these studies since laboratory conditions are not the same as those, which occur in the mouth. Amongst the studies the source of hard tissue substance was different, and there were also differences in the method of preparation of the substrate as well as in the methods of evaluating dental erosion.

Taken together, it may be concluded that the evidence of differing types of study has been consistent in demonstrating erosive potential amongst some dietary items. In many cases studies have been focused particularly on fruit juices and fruit based drinks, carbonated and sports drinks and foods with low pH, especially fruits. Present data does not yet allow ranking of different acids with regard to their erosive potential.

III) Dietary Supplements, Medications and Oral Hygiene Products

As well as dietary items, low pH dietary supplements, medications and oral hygiene products may carry the potential to cause dental erosion. Dietary supplements implicated in erosion include iron and Vitamin C (ascorbic acid) supplements. There have been reports of erosion being related to a number of medicines of low pH including aspirin, hydrochloric acid, and some drug treatments for asthma. Amongst oral hygiene products, an anti-calculus mouthrinse containing ethylenediamine-tetraacetic acid (EDTA) has been found to have a marked enamel erosive effect. Questions have also been raised about the erosive potential of saliva substitutes with a low pH, and about products intended to stimulate saliva flow which contain citric or malic acid (Rytomaa et al 1989).

As with the diet, the manner and frequency of use of medicines of low pH are likely to be of overriding importance. Most medications are used at intervals and only for short periods, reducing their erosive effect but this is not always true. In the case of achlorhydria for example patients may need to take dilute hydrochloric acid several times a day for extended periods (Stafne & Lovestedt 1947, Smith 1989). A particular risk may occur when drugs or acidic agents designed to stimulate saliva production are given to those with reduced salivary flow (James & Parfitt 1953, Giunta 1983, Sullivan & Kramer 1983).

Patients with asthma may also be at particularly high risk of erosion. The prevalence of asthma in children is high and prophylactic and symptomatic drug treatments are common (O'Sullivan & Curzon 1998). Not only is there a risk to patients posed by frequent use of oral drugs of low pH, but an additional risk may arise from gastro-oesophageal reflux. An increased incidence of gastro-oesophageal reflux has been reported in subjects with asthma (O'Sullivan & Curzon 1998).

2.2.2 Intrinsic Factors

Dental erosion is caused not only by exogenic acids but also by the effect of gastric acids or acidic gastric contents reaching the oral cavity and the teeth as a result of vomiting, regurgitation, gastro-esophageal reflux or rumination.

The pH value of gastric acid is 1-1.5, well below the 5.5 level critical for the dissolving of dental enamel and the risk of erosion has, for example, been reported to be 18 times higher in patients with chronic vomiting compared with non-vomiting patients. Frequency of the occurrence is important, vomiting once a week or more was associated

with an erosion risk 31 times greater than that in patients who vomited less frequently than once a week (Jarvinen et al 1991).

Causes of repeated vomiting or gastric regurgitation are listed in Table 2.3. In the majority of cases, regurgitation is involuntary but in some eating disorders and in rumination it may be regarded as voluntary.

Table 2.3 **General causes of regurgitation**

1. Upper Gastrointestinal disorders
   - hiatus hernia
   - gastroesophageal reflux and cerebral palsy
   - esophageal diverticulosis
   - duodenal ulcers
2. Metabolic and endocrine disorders
   - e.g diabetes mellitus
3. Drug therapy; indirect side-effect of drugs (e.g cytotoxic drugs)
4. Radiotherapy
5. Alcoholism
6. Eating disorders
   - Anorexia nervosa
   - Bulimia
   - Stress-induced
   - Rumination

All disorders associated with vomiting, regurgitation or gastro-esophageal reflux and rumination may result in erosion of the dental hard tissues from the effect of gastric acid on the teeth but clinical manifestations do not usually occur until gastric acid has acted on the dental hard tissues regularly several times a week for a period of at least 1-2 year (Stafne & Lovestedt 1947, Hellstorm 1977, Bartlett & Smith 1994). It is believed that saliva, depending on its flow rate and buffer capacity may act as a mitigating factor in the aetiology of dental erosion even in these cases of severe challenge.

Erosion and gastric regurgitation in children

At one time it was thought that erosion due to reflux activity was very rare in children. The common conditions that cause reflux in adults are sickness in pregnancy, chronic indigestion and 'heart burn', hiatus hernia and chronic alcoholism, are rare conditions in children (Shaw & Smith 1994).

However, long-term regurgitation in young patients has more recently been associated with a variety of underlying problems. It has been suggested that the prevalence of regurgitation in childhood is increasing but it may be that it is simply being recognised and diagnosed more frequently (Shaw & Smith 1994). Causes have been reviewed and a list of conditions modified from the review is reproduced below (Table 2.4).

Table 2.4 **Conditions in children associated with chronic regurgitation**

(modified from Kilpatrick and Welbury 1997)

Gastro-oesophageal reflux including gastro-oesophageal reflux disease (GORD)
Oesophageal stricture
Chronic respiratory disease e.g asthma, recurrent obstructive bronchitis, recurrent pneumonia
Disease of the liver/pancreas/biliary tree
Over-feeding
Feeding problems/ failure to thrive conditions
Children with mental handicap
Reye's syndrome
Rumination

In children intrinsic causes may arise particularly during infancy. Erosion in cases of cerebral palsy and as a result of eating disorders have also received particular attention. Regurgitation in early infancy is common but does not usually persist. Long-term regurgitation is associated with: learning difficulties, failure to thrive, feeding problems, oesophagitis, anaemia, stricture formation, or recurrent pneumonia secondary to aspiration.

Early recognition of these disorders is of paramount importance so that related problems, including dental erosion, can be prevented (Shaw & Smith 1994).

The association between learning difficulties (mental handicap) and gastro-oesophageal reflux was first made in 1957. There is now some evidence to link cerebral palsy with reflux activity. The cause of regurgitation in affected people is unknown. Several possible contributory factors have been reported, such as: incoordination of swallowing, kyphoscoliosis, prolonged recumbence, and the presence of extension spasms, all of which may be present in people with cerebral palsy. Very severe tooth wear is often seen and is believed to occur through a combination of erosion and attrition due to bruxism.

Erosion has come to be recognised as a characteristic feature of eating disorders. Three types of eating disorders may be seen in children and young people, bulimia nervosa, anorexia nervosa, and more rarely rumination. Awareness and reporting of eating disorders has increased and estimates suggest that their prevalence is rising. Bulimia nervosa is thought to affect between 1 and 4% of white females between 18 and 30 years in Western industrialised countries. Anorexia is less common than bulimia, affecting between 0.5 and 1% of white females of 11-18 years of age (Shaw & Smith 1994). The prevalence of eating disorders appears to be greater in certain groups such as adolescent girls, ballet dancers, dieters and in Asian women. Subjects often attempt to prevent their bulimic problem from being discovered and may not present with dental problems specific to their bulimia until the problem has been present for years, although signs may be obvious after 6 months (Abrams and Ruff 1986).

The diagnostic criteria for erosion resulting from eating disorders have been listed as:

- extensive erosion of the palatal aspects of the upper anterior teeth.
- moderate erosion of the buccal surfaces of the upper anterior teeth.

- the lingual surfaces of the lower anterior and posterior teeth are virtually unaffected
- erosion of the palatal aspect of the upper posterior teeth.
- variable erosion of the occlusal and buccal surfaces of the upper and lower posterior teeth.
- restorations standing proud of the eroded surfaces.
- absence of staining on eroded surfaces (Robb et al 1995).

The erosive outcomes of these disorders have been described in the permanent dentition but not in primary teeth, although eating disorders have been described in younger children (Schulze et al 1999).

2.2.3 Life Style and Behavioural Factors

Lifestyle may represent a determinant of erosion in the case of intrinsic and extrinsic causes. In the case of extrinsic causes, lifestyle relates to the types of foods and beverages consumed, the frequency and time of consumption. Oral hygiene practices particularly tooth-brushing habits may also be important. The combination of frequent consumption of acidic foods and drinks and overzealous oral hygiene practices may particularly represent a high risk factor (Zero 1996). Similarly, inappropriate toothbrushing may exacerbate the effects of gastric acid. This is thought to be an important factor in determining the erosion occurring in patients with eating disorders.

- ***Dietary habits***

Soft drink consumption has increased dramatically over the past 40 years to a 151 litres per capita of the population in the United Kingdom in 1991. Adolescents account for up to 65% of this value. Pure fruit juices contribute to the total but, increasingly,

carbonated drinks make up a large part of the younger population's intake. These are now widely available in vending machines located in schools, sport centres, and other public areas. Excessive ingestion of acidic fruit juices or acidic beverages on a daily basis has been linked to excessive dental erosion (Lewis & Smith 1973).

Unusual eating, drinking and swallowing habits, and parafunctional habits, especially those which increase the direct contact time of acidic foods and beverages with the teeth, are also factors that may also increase the risk of dental erosion (Lewis & Smith1973, High 1977, Mackie & Hobson 1986, Asher & Read 1987, Harrison & Roder 1991, Smith & Shaw 1987, Millward et al 1994 a).

Parafunctional habits causing dental erosion that have been reported in the past include holding a carbonated drink in the mouth for some time (High 1977), swishing concentrated orange cordial and carbonated cola beverage between the teeth before swallowing or drinking through a straw or infant feeding cup placed against the labial surface of maxillary anterior teeth (Mackie & Hobson 1986, Harrison & Roder 1991).

Drinks from a feeder cup or straw may not necessarily be erosive in themselves since drinks from a glass take longer to clear from the mouth (Shaw and Smith 1994). It is suggested that drinking acidic beverage through a straw place orally inside the mouth, may reduce the erosive potential as it by passes the teeth (Nunn et al 1996).

Timing of drinks is important and the consumption of acidic beverages at bedtime has also been implicated in erosion (Millward et al 1994 a).

It has been suggested that drinking behaviour may be related to socioeconomic status. In one study of 4 years old children, those from a lower socioeconomic group had less erosion than children from higher socioeconomic groups. However, the difference may be as much related to variation in dietary patterns and/or oral hygiene practices as to drinking habits (Millward et al 1994 a).

- ***Promotion of 'Healthier' life style***

Messages that are intended to promote "healthier" life styles may affect erosion indirectly through their effects on diet, exercise and weight control. Current messages for healthy diets encourage consumption of more fruits and vegetables. Healthier diets may therefore include greater consumption of acidic foods. It is suggested that, carried to excess, this has been associated with a higher prevalence of dental erosion (Linkosalo & Markkanen 1985).

Individuals pursuing sporting activities may also be at higher risk of dental erosion since they may be encouraged towards more frequent ingestion of acidic sports drinks and other acidic beverages, which may not be necessary but are promoted through advertising.

High consumption of citrus fruits and fruit juices may also be part of weight reduction plans. Individuals with eating disorders, such as bulimia, may compound the effects of gastric acid from regurgitation with the consumption of large quantities of citrus fruits and juices or carbonated soft drinks.

- ***Oral hygiene practice***

Another aspect which may affect dental erosion, is cleaning the teeth. Tooth surfaces that are accessible to natural cleansing forces and the action of a tooth brush are prone to erosion, while the opposite of this is true for dental caries. Oral hygiene practices are considered a contributing factor in tooth wear (Zero 1996). Thus the loss of tooth substance after exposure to citrus fruit juice is accelerated by tooth brushing (Davis & Winter 1980).

If demineralized tissue is brushed, even with a brush and water, abrasion may be accelerated until the demineralized layers are removed. The effects of repeatedly

consuming acidic foods and drinks followed by tooth brushing may be very important as far as erosion is concerned (Shaw and Smith 1994).

2.3 Protective Factors Against Erosion

Factors which may act to protect against erosion or to mitigate against the effects of acid include saliva and salivary pellicle and fluoride.

- **Saliva and salivary pellicle**

Saliva and salivary pellicle have potential to counteract acid attack and protect the dentition against erosion and may do so through a variety of mechanisms. These include:

- Increased salivary flow helping to dilute acids in the mouth, which also leads to their rapid removal by swallowing.
- Salivary buffers partly neutralising the acids in the oral fluid.
- The calcium and phosphate levels in the saliva acting as common ions to the minerals in enamel and dentine, resulting in a slower dissolution rate of mineral.
- Salivary mineral ions may also reprecipitate during a remineralization of the erosive lesions.
- Salivary mucins and other organic components forming a pellicle on the tooth surface, which inhibits or slows down mineral loss during acid dissolution.
- Saliva production increasing by the acid induced stimulation of the salivary glands (Meurman and ten Cate 1996).

- **Fluoride**

The action of fluoride on resistance of enamel to dental erosion has been investigated in several studies. It was found that, 50 ppm fluoride ions added to grapefruit juice achieved a 60% reduction in tooth erosion in rats (Spencer & Ellis 1950), and as little as 2 ppm fluoride has been shown to produce some protection in these experimental animals (Holloway et al 1958). In another in vitro study on enamel erosion, fluoride when added to a citrus drink produced a 30% drop in caries in children. It was also reported to affect erosion (Gedalia et al 1981). Topical treatment with concentrated fluoride varnish was shown to inhibit softening of human molar enamel in vitro (Sorvari et al 1994) and fluoride mouthwashes have been used empirically in the treatment of dental erosion (Imfeld 1996).

In a recent study to investigate the effect of fluoridation during childhood in an Australian population, it was found that fluoride exposure in the first 12 years of life appears to confer some resistance to excessive tooth wear from acid erosion in adulthood, as it does for resistance to demineralization by dental caries. However, other factors, such as salivary protection of the teeth against acid attack, were thought to influence the sites which are affected by erosion (Teo et al 1997).

Whether the mechanism of protection against acid demineralization is the presence of fluoride ion in the apatite, or in the ambient plaque fluid or saliva, fluoride ion may well confer protection at around the critical pH of 4.5 (Larsen 1973, Teo et al 1997).

However, consensus has not yet been achieved as to how effective fluorides are in preventing the progression of erosive lesions. In addition it is not yet established how chemical and structural components of tooth tissue in general might modify this pathological process.

2.4 Erosion and Dental Caries

The mechanism of the destructive pathology in erosion and caries is similar, namely dissolution of apatite crystals, but it is reported that these two pathologies rarely occur simultaneously (Meurman and ten Cate 1996). Erosion and caries differ in the nature of the lesion, the sites most frequently affected and the involvement of plaque flora.
One of the characteristic features of an early carious lesion of enamel is that the lesion is subsurface; that is, most of the mineral loss occurs beneath a relatively intact enamel surface. This contrasts strongly with the histological appearance of enamel after a clean tooth surface has been exposed to acid, where the surface is etched and there is no subsurface lesion. Erosion, at least in experimental conditions, is therefore primarily a surface phenomenon while caries begins as subsurface demineralisation of enamel structure (Meurman and ten Cate 1996).

Caries occurs on plaque-covered sites. Although it may affect any tooth surface, fissures, approximal surfaces and the cervical third of free smooth surfaces are affected the most often. These represent sites where plaque may accumulate and remain undisturbed over time. In contrast, erosion most often affects free smooth surfaces and is often seen to involve incisal edges and cusps of occlusal surfaces.

Plaque acts as a partial barrier to acid diffusion to and from the enamel surface. Although the volume and concentration of acids affecting the surfaces may be greater in erosion, this may not be true on the very localised scale at which caries develops. The presence of plaque may also result in acid being retained for longer than erosion, in which teeth are effectively 'rinsed' by acids (Meurman and ten Cate 1996).

Depending on the strength and frequency of erosive challenges, no plaque micro-organisms can tolerate the very low pHs thought to act in erosion. Many acidic foodstuffs and drinks have pH values below 3, and the pH of gastric contents is around 1-1.5. Even the most cariogenic mutans streptococci cease to metabolise at pH values below 4.2 (Michalek and McGhee 1982). These factors have been used to explain why erosion and caries are usually not seen on the same tooth surfaces. However many dietary items with some erosive potential also carry a high cariogenic challenge.

In some cases, carious destruction of tooth tissue may be very rapid, effectively masking the presence of erosion occurring at a slower rate in the same tooth. Similarly, restorations may hide the presence of erosive lesions. The two pathologies may also not always have been investigated together.

3. Description and Measurement of Erosion

Measurement of erosion has proved difficult, particularly for purposes of epidemiology. Erosion has been assessed in the simplest terms as a description of clinical findings. Sometimes dietary and/or clinical histories have been added to aid differentiation. However, more complex grading systems have also been described. These have included scales of severity.

Perhaps because they cannot always be distinguished, there has not always been a distinction drawn between abrasion, attrition and erosion. The more recently developed indices of 'tooth wear' reflect this factor in that they do not attempt to separate the three underlying mechanisms. As well as systems used for measurement at clinical assessment, others have been designed for use in in-vitro studies.

3.1 Descriptive Systems

In at least five reports, assessment of erosion rested simply on clinical examination (Watson & Tulloch 1985, White et al 1978, Andrews 1982, Johnson & Sivers 1987, Mackie & Blinkhorn 1989). Although it is often difficult to determine the principal aetiological factor related to tooth surface loss, it has been frequently suggested that a detailed case history is important in assessing the nature and duration of the problem (Watson & Tulloch 1985). Diagnosis has rested largely on history in other studies also (White et al in 1978, Andrew 1982).

The clinical features of erosion, detailed by means of the appearance of tooth surface as wear/erosion, but without scales of recording, was reviewed by Johnson & Sivers in 1987.

In one study, plaster study casts were included in the investigation of erosion. A detailed history was taken including a 3-day diet diary completed by the patient. Differential diagnosis for trauma, abrasion, bruxism and erosion was made by making upper and lower study casts so that the tissue loss could be examined more closely, leading to a provisional diagnosis of dental erosion, but no attempt was made to define any systematic grading system (Mackie & Blinkhorn 1989).

3.2 Grading Systems

Of the grading systems introduced for scoring erosion, three were devised for experimental work in animal models and four for use in epidemiological studies in children.

Systems devised for animal models

One of the first grading systems for erosion was defined more than 50 years ago in an animal model. The destruction of molar teeth was assessed in a study using rats (Restarski et al 1945). The authors defined a series of 6 grades to evaluate loss of enamel, these are summarised in Table 2.5.

Table 2.5 **A grading system to evaluate the destruction of each molar on rats** (Restarski, Gortner, McCay 1945)

Score	Criteria
0	No effect
1	High polish of enamel
2	Slight etching of lingual enamel
3	Mild destruction of lingual enamel, evidence of slight ridge formation at gingival margin
4	Moderate destruction of lingual enamel, ridging more definite, Some exposure of dentine
5	Severe destruction of lingual enamel, marked ridge at gingival margin, moderate exposure of dentine
6	Almost complete destruction of lingual enamel with definite evidence of destruction on other surfaces, marked exposure of dentine with some destruction

Loss ranged from 0, where there is no effect, through slight etching of the enamel (scored as 2) to almost complete destruction of lingual enamel with evidence of destruction on other surfaces (scored as 6). Some of the criteria are similar to those included in more recent studies.

A modification of this system was made by Hartles & Wagg in 1962 again for evaluating erosion in rats using detailed 'subjective' and 'objective' methods. The subjective method made use of low-power binocular microscope to classify damage to the teeth as shown in Table 2.6.

Table 2.6 **Evaluating erosion in rats using detailed 'subjective' methods**

(Hartles & Wagg 1962)

Score	Criteria
0	Normal tooth
1	Lingual enamel highly polished; slightly loss of contour of lingual cusps.
2	Slightly etching of lingual enamel at gingival margin of exposed crown; slightly rounding of occlusal edge of cusps.
3	Beginning of ridge or shelf at gingival margin on the lingual enamel; mild destruction of lingual enamel.
4	Moderate destruction of lingual enamel with some exposure of dentine producing a definite ridge; island of exposed dentine in centre of cusps.
5	Severe destruction of lingual enamel with exposure of dentine from the gingival margin to the occlusal surface; marked ridge at gingival margin.
6	Complete destruction of lingual enamel of exposed crown to form a continuous ridge at the gingival margin; some destruction of dentine.

In the objective method, in addition to examining erosion of the tooth surface, the enamel thickness was measured. A method was given of mounting the first and second molars and sectioning them with a diamond cutting-wheel, making a transverse cut across the centre cusp of the first molar and the rear cusp of the second molar. After staining to differentiate enamel from dentine, the buccal and lingual enamel thickness were measured (Hartles &Wagg 1962).

The third grading system was a simplified grading of erosion in laboratory rats. Under ×20 magnification the lingual surfaces of each maxillary molar and the first mandibular molar were separated mesiodistally into three regions. Surfaces of second and third mandibular molars were divided into two zones. The 32 areas for each rat were awarded values on the following scale shown in Table 2.7.

Table 2.7 **Simplified grading of erosion in laboratory rats**

(McDonald & Stookey 1973)

Score	Criteria
0	No erosion
1	Slight erosion, limited to enamel
2	Spot erosion with exposed dentine
3	Lingual enamel gone (shelf formation)
4	Erosion extended onto the buccal surface
5	Massive erosion with reduction in cusp height and tooth volume

The mean value for each maxillary tooth added to that for each mandibular tooth gave the total mean severity score per rat (McDonald & Stookey 1973).

II) Systems for use in epidemiological studies

At least four systems of grading have been introduced to measure erosion. The first of these was developed in a survey on tooth erosion carried out by Eccles & Jenkins in 1974. The authors described the appearance and distribution of lesions and related these to dietary factors. The survey included a clinical examination of the patient, photographs and a questionnaire covering principally the pattern of diet and oral hygiene. Teeth were graded according to the severity of loss using the scale shown in Table 2.8.

Table 2.8 **A grading system according to the severity of the lesions**

(Eccles & Jenkins 1974)

Score	Description
0	No involvement
1	Loss of surface features of the labial, lingual or occlusal enamel surfaces, giving a smooth glazed appearance. The dentine is not involved.
2	Involvement of the dentine for less than 1/3 of the area of the tooth surface.
3	Involvement of the dentine for more than 1/3 of the area of the tooth surface.

The second system was a modification of this classification of dental erosion and was described 5 years later in 1979 (Eccles 1979). The scale used in this modified system is reproduced in Table 2.9.

Table 2.9 **Classification of dental erosion**

(Eccles 1979)

Score	Description
Class 1	superficial lesion-involving enamel only
Class 2	Localised lesion-involving dentine for less than 1/3 of the surface
Class 3	Generalized lesions-involving dentine for more than 1/3 of the surface a)facial surfaces b)lingual and palatal surfaces c)incisal and occlusal surfaces d)severe multisurface involvement

A third grading assessment of severity of erosion devised for use in children was devised more recently in a study of cases of dental erosion in children with gastroesophageal reflux disease (Aine et al 1993). Cases were classified according to their clinical appearance as shown in Table 2.10.

Table 2.10 **Classification of primary and permanent teeth erosions caused by gastroesophageal reflux disease** (Aine, Baer, Maki 1993)

Grading of Erosion	Type of Erosion
0	No erosion
1	Mild opacities or white spots/etched appearances.
2	Occlusal surfaces filled with small holes (punched -out-appearances) incisal edges thinned, flattening of cusps.
3	Dentine exposure at the bottom of the holes on occlusal surfaces or dentine affected on other surfaces.

This grading for dental erosion was considered suitable for children with primary, mixed, or permanent dentitions. Primary incisors characteristically showed white spots or an etched appearance and the incisal edges of anterior teeth were thinned and grooved. Chalky and opaque lesions were seen all over the primary teeth. However the most typical changes were small holes or pits on the occlusal surfaces of primary molars. In mild forms these were confined to enamel but in the more severe cases, the cupping became extensive and a part or the whole of the occlusal surface could be affected. It was characteristic that in primary dentitions the occlusal surface seemed to show the most prominent changes with cupping or loss of structure, leaving areas with a punched-out-appearance (Aine et al 1993). This grading is more difficult to use as it includes looking at molar teeth in young children.

The fourth method of grading erosion was that used in the National Survey of Child Dental Health in 1993 (O'Brien 1994) and in the Nutritional Survey of 1½ to 4½ year olds (Hinds & Gregory 1995). These studies involved examination of four teeth per child for depth and area of erosion. They were both employed on large samples.

Buccal and lingual surfaces of the primary or permanent maxillary incisors (BA|AB),(52,51,61,62) and (21|12),(12,11,21,22) were assessed for loss of surface enamel characteristic and/or exposure of dentine or pulp. Teeth were scored using the criteria summarised in Table 2.11.

Table 2.11 **Assessment of 4 teeth per child for depth and area of erosion**

(O'Brien 1994)

Depth	0 Normal
	1 Enamel only - loss of surface characterisation
	2 Enamel and dentine - loss of enamel, exposing dentine
	3 Enamel into pulp - loss of enamel and dentine resulting in pulp exposure
	9 Assessment cannot be made
Area	0 Normal
	1 < 1/3 of surface involved
	2 1/3 - 2/3 of surface involved
	3 > 2/3 of surface involved
	9 Assessment cannot be made

This index was a modification of Smith & Knight's index for tooth wear (see below), but assessing the amount of tooth surface loss only from the palatal and buccal surfaces of maxillary incisor teeth in the primary and permanent dentitions. Results from the

calibration exercise conducted during the dentists' training for the survey showed standard deviations of 0.39 to 2.04 about mean values of 0.53 - 2.64, indicating that dentists found it difficult to agree in determining the presence of erosion. Erosion confined to enamel may have been especially difficult. Erosion into dentine and the dental pulp may be easier to identify. It's importance, in terms of treatment implication may also be greater.

A year later examiners in the National Diet and Nutrition Survey of children aged 1½ to 4½ years used the same criteria. This survey had accompanied a large diet and nutrition enquiry and included a total of 1522 children. However, although criteria were the same, the training of dentists for the school and pre-school children's dental health surveys differed, dentists working on the former attended a two-day residential course while those on the latter attended only a one-day briefing and had been supplied with less detailed written instructions.

3.3 Indices of Tooth Wear

Some studies have included measurement of all types of wear. In one of these an index was devised to describe the degree of incisal and occlusal wear on a simple ordinal scale from 0 to 3, representing wear as follow:

0 negligible or no wear

1 obvious wear of enamel or wear through the enamel to dentine in single spots

2 wear of dentine up to 1/3 of the crown height

3 wear of dentine more than 1/3 of the crown height and/or excessive wear of tooth restorative material (Hugoson et al 1988).

It has been suggested that this index lacks sensitivity because it is confined to such a narrow range of scores (Donachie & Walls 1996). Other studies have used more complicated systems.

Tooth wear as whole, with erosion as one component, was evaluated by Oilo et al in 1987 and again by Dahl et al in 1989, using an index based on an earlier system devised by Ryge primarily for rating the quality of restorations. The system included a decision on whether treatment is necessary. Two designations, (satisfactory) and (not acceptable) were used and each was broken into categories that were rated on the basis of surface and colour, anatomic form, and marginal integrity (Ryge & Snyder 1973).

From this Oilo et al in 1987 developed an index for estimating tooth wear that was expanded to include three satisfactory categories and two unacceptable ones. These are shown in Table 2.12.

Table 2.12 **Rating system for occlusal wear**

(Oilo et al 1987)

Rating	Occlusal wear
Satisfactory	
R Romeo	no visible wear
S Sierra	occlusal or incisal wear facets in enamel small area of exposed dentine without change of hardness or sensitivity
M Mike	obvious length reduction of tooth large areas of exposed dentine discoloured but without change of hardness or sensitivity
Not acceptable	
T Tango	considerable length reduction of tooth large areas of exposed dentine which is discoloured , soft and/or sensitive
V Victor	marked length reduction of tooth tooth structure and/or restorations fractured due to excessive wear softening of exposed dentine pulp exposure from wear pain on chewing irritation of gingiva and/or oral mucous membranes

The system was applicable both to restorations and to tooth tissues. In a later modification of the same system, the 3 categories of wear described as satisfactory (R, S and M) and the 2 categories of degree of wear were deemed unacceptable (T and V) were retained but to overcome the problem of grading the wear of restorations, two extra subcategories of group M were introduced in addition to those described previously. The new ones were: large wear facets in restorative material (MWR) and perforation of crown with hard, non-sensitive dentine exposed (MED-P). This system was again applicable to any tooth surface or restoration (Dahl et al 1989).

3.3.1 Tooth Wear Index (TWI)

The tooth wear index (TWI), which was first described in 1984, attempted to provide a solution to some of the problems of measuring the wear of teeth at the level of the

individual as well as that of the community. In this method, all surfaces of all teeth are examined, with the exception of interproximal surfaces, and scored from 0 to 4. Separate records are made of the cervical surface, the remainder of the buccal or labial surface, the lingual or palatal surface, and the occlusal or incisal surface. The effect of tooth wear on occlusal and incisal surfaces is not the same, so different criteria are used. The buccal and cervical surfaces are recorded separately because of the occurrence of cervical notch defects in some patients which may not be associated with wear of the entire buccal surface and which probably have a different aetiology. The total number of surfaces to be recorded was therefore 4 per tooth × 32 teeth =128 surfaces per patient. The index was reported to show satisfactory reproducibility and to provide sufficient sensitivity to allow specific pattern of wear to be distinguished. TWI scoring criteria are shown in Table 2.13.

Table 2.13 **TWI scoring criteria**

(Smith & Knight 1984)

Score	Buccal, lingual, occlusal	Incisal	Cervical
0	no loss of enamel surface characteristics	no loss of enamel characteristics	no change in contour
1	loss of enamel surface characteristics	loss of enamel surface characteristics	minimal loss of contour
2	loss of enamel exposing dentine for <1/3 of the surface	loss of enamel just exposing dentine	defect <1mm deep
3	loss of enamel exposing dentine for >1/3 of the surface	loss of enamel and substantial loss of dentine but not exposing pulp or secondary dentine	defect 1-2mm deep
4	complete loss of enamel or pulp exposure or exposure of secondary dentine	pulp exposure or exposure of secondary dentine	defect >2mm deep or pulp exposure or exposure of secondary dentine

TWI was designed primarily for use in research into the aetiology, prevention and management of tooth wear problems, both in epidemiological studies and in long-term monitoring of tooth wear in individual patients.

The same index has also been employed to investigate tooth tissue loss in children associated with the excessive consumption of citric acid. In addition to the clinical examination used in previous studies employing TWI, both study models and photographic methods were employed to aid assessment in the study of Asher & Read in 1987. The authors concluded that where pathological tooth wear is diagnosed, serial study models may be useful to check the prevention of progression of the eroded defects. The photographs were a very crude measure in that where relevant, patients were asked whether they had photographs at home which would show shortening or a change of shape in the incisors over a period of time. Only in one case was a series of three annual school photographs used to confirm that the incisal edges of the upper two central incisors had been reduced, producing a V-shaped defect between the two teeth.

3.3.2 Modification of the TWI index

A modification of the TWI has been used in at least 2 studies. In 1994 this was employed in a study of tooth wear in 4 years old children (Millward et al 1994 a). It was assumed that loss was a consequence of erosion. From the assessment, children were classified into 3 groups; low erosion - scores of 0 and 1 for all teeth, moderate erosion - any surfaces with scores of 2, severe erosion - any surfaces with scores of 3 and/or 4. The incisal edge of primary incisor and canine teeth were excluded as these surfaces

were subject to attrition. This method was later used by the same authors to study erosion in a much wider age range of 4 to 16 ½ years olds in relation to drinking habits (Millward et al 1994 b).

Summary

All systems and indices describe morphological changes with up to seven grades of severity. Choice of system will depend partly on the aim of the study. Even though a fine-step grading scheme may be thought to have the potential to demonstrate minute changes of the dental hard tissues, it may well show lesser inter- and intra-examiner agreement and thus reduce reliability of findings and complicate comparisons between studies. The use of a very fine grading scale will also prolong the decision process for every individual tooth and thus be more time consuming. As well as being less reliable in use and more time consuming in use, a more complex grading methods may make analysis of results more complex. Provided that they detect changes sought in a given study, simpler indices may offer advantages in epidemiological studies, especially if these are large.

Not all indices distinguish between the differing causes of wear. Whilst it may not be possible to differentiate exactly between types, and these systems may be easier to use in consequence, they may fail to detect levels of wear that are primarily a result of erosion. Abrasion in the primary dentition is thought to be uncommon, attrition is almost always evident by the time of exfoliation but is thought to be seen primarily on the incisal edges and occlusal surfaces. Previous studies which have been focused on wear that is primarily erosive have therefore used systems where scoring is confined to

smooth surfaces of incisor teeth where other causes may be less likely (O'Brien 1994, Hinds & Gregory 1995, Millward et al 1994 a).

Studies have included determinations of the reproducibility of such indices but there has been little study of the extent to which scores relate to findings in vitro, where different systems have been employed.

3.4 Methods of Assessing Erosion and Erosive Potential Used in Vitro

In devising methods of assessment most attention has been focused on scoring methods and indices for use in vivo. Thus, what is assessed on extracted teeth or in dental hard tissues used in research has often related to erosive potential, whereas studies of teeth in situ in the mouth are examined for erosion that has occurred during life.

The methods used for measurement in vitro may be considered as those used for examination of extracted teeth, chemical methods, physical methods, methods based on iodide permeability tests, digital image analysis, scanning electron microscopy and other useful techniques.

1) Examination of Extracted Teeth

If whole human teeth are to be examined for erosion, the methods may be based on those used in vivo. A point of difference would be that whereas in vivo a part or the whole of the dentition may be studied and assessed for erosion, observations after extraction may need to be based on single tooth or small groups of teeth. This requires adherence to set criteria and use of the same tooth type on each occasion. A further

drawback in using extracted teeth is that their history and the likely aetiology of any erosion are unlikely to be known (Grenby 1996).

2) Chemical Methods

Much of the research on the acidity of drinks and their potential erosiveness has not used dental hard tissue, and has been based solely on measurement of changing pH in oral or dental plaque. A more sensitive way of showing small changes indicative of erosion under laboratory conditions is to measure calcium and/or phosphorus dissolving from teeth or dental mineral under the influence of potentially erosive acids or other erosive factors. A standard test needs to be devised, such as exposing a tooth or tooth material to the erosive agent or environment for a set length of time, before using the erosive medium for analysis to detect the calcium or phosphorus released. Initial and final figures are required so that 'blanks' (initial concentrations of Ca and P before any dissolves from the tooth mineral) can be subtracted from the final Ca and P levels. A variety of small-scale and micro-methods exist for the determination of Ca and P in solution. Phosphorus levels in solution have been measured by causing the formation of phosphomolybdic acid. This salt is subsequently reduced to a blue compound which may be measured colorimetrically (Allen 1940).

One reliable and sensitive technique for estimating calcium with little interference from other solutes is by atomic absorption spectroscopy (Grenby et al 1990). Using this method, the amount of calcium release from enamel after repeated exposure to erosive fruits over a 40 minutes period was determined by Grobler et al in 1989.

Atomic absorption spectroscopy was also used to investigate the effects of some "sports drinks" (drinks marketed as providing rapidly available sources of energy in appropriate

form) on dental enamel in vitro. Bovine tooth specimens were employed. The drinks, which have low pH and high titratable acidity, were tested for their capacity to dissolve hydroxyapatite (the inorganic component of enamel). To measure calcium release, 5 mg hydroxyapatite was added to 5 ml of each drink to be tested in small plastic tubes. The tubes were shaken for 30 min at room temperature and then centrifuged for 15 min at 9500×g. The Calcium ion concentration in the supernatant was then measured (Meurman et al 1990).

A drawback to using these methods is that they do not mirror conditions in vivo where other factors such as saliva may act to modify the process.

3) Physical Methods

Physical methods of determining erosion in vitro depend on direct examination and assessment of the condition of a tooth surface or tooth material. As do other methods, these require some form of scale to be set for the purpose of quantifying erosion.

a) Polarised Light Microscopy

Microscopic examination of the teeth under polarised light was used in an investigation into the possible effects of baby fruit juice on tooth erosion, extracted primary teeth were completely coated with nail-varnish with the exception of a window on the enamel of approximately 4×4 mm. The extracted teeth were placed in samples of the undiluted baby fruit juices at room temperature overnight (15 hours). On removal from the juice, the teeth were rinsed with water, dried, and the nail-varnish removed with acetone. The window area on the enamel was examined macroscopically for any change in appearance of the surface enamel prior to preparation of sections.

Overnight immersion of the teeth in the juices gave rise to lesions of 'white spot' macroscopic appearance. The surface of the lesions was chalky and opaque, in contrast to the adjacent untreated, sound enamel. Sections were mounted in canada balsam and viewed under polarised light. Sections of these teeth when viewed under polarised light conditions indicated that appreciable destruction of the enamel had occurred. Complete loss of surface enamel had taken place and the lesion surface appeared irregular. Beneath this surface, there was a zone of the enamel which had a translucent appearance under polarised light, reminiscent of the translucent zone seen in early enamel caries. The macroscopic appearance of the lesion was one of gross demineralisation, and the translucent appearance of the enamel beneath the lesion surface suggested that diffusion of the juice into the enamel had occurred, giving rise to partial dissolution of the tissues (Smith & Shaw 1987).

In a more recent investigation, erosion was investigated in incisor teeth in cattle. The surface of the affected teeth were initially examined by stereomicroscopy, loss of enamel was of a flaking appearance rather than the pitting normally seen in human dental erosion. To investigate the mineral loss and other structural alterations, ground undemineralised sections of the affected teeth were prepared, mounted in quinoline and examined by polarised light microscopy. Comparison with normal bovine teeth indicated loss of mineral in the areas of erosive lesions, but no apparent structural differences to the sound enamel. This suggests the absence of any developmental anomaly, which might be thought to make the teeth more susceptible to erosion or other mechanisms of destruction (Smith et al 1992).

b) Surface Profilometric Analysis

Surface profilometric analysis has been used to assess the degree of enamel erosion in at least two studies (Rytomaa et al 1988, Meurman et al 1990). Surface profile measurement was used to evaluate the depth of enamel erosion after exposure to acidic drinks and milk products for 4 hours under constant agitation. The loss of material after erosive exposure was measured by recording the surface profile of the parallel enamel blocks using a Dektac profilometer. The readings was digitalized and computerised in order to make graphs which could be zoomed and scaled as required (Rytomaa et al 1988). Exactly the same method was used in a second investigation to measure loss of tooth material after a period of immersion in some sports drinks. The computerised data were used to analyse surface alterations caused by erosion, and respective profiles at control and test areas were drawn and compared (Meurman et al 1990).

c) Surface Microhardness (SMH) Measurements

Measurement of surface microhardness has been more often used to study the demineralization / remineralization process that is thought to represent early caries than to investigate erosion. Initial demineralization is characterised by surface softening with dissolution of prism peripheries, with no subsurface lesion formation taking place. In this case surface microhardness (SMH) is sensitive enough for shallow lesions, provided that the lesions are less than 50μm deep at any time during the study. Decrease in Knoop hardness has been linearly related to mineral loss under conditions of mild demineralization, a linear relationship between change in penetration depth and mineral loss has been demonstrated for a wide range of demineralizing conditions (Feagin et al 1969, Koulourides 1971). In the study of Meurman et al in 1990 on the affect of some

sports drinks, as well as using surface profilometry, surface hardness was measured by using microhardness identation equipment. Five well-formed identations were recorded at each measurement site, both at the control and test areas of each specimen (Meurman et al 1990).

Surface microhardness was measured more recently in a study of erosion carried out by Lussi et al in 1993, using caries-free human premolars. The crowns were separated from the roots, and the buccal sites were ground flat under water cooling on a rotating polishing machine. Embedded enamel blocks in resin, were fixed on a glass slide with double-sided adhesive tape. Hardness measurements were performed before and after exposure to certain beverage and food stuffs. Identations were made with the long axis parallel of the vertical border of the window at intervals of 25 or 50μm. The length of the indentation was measured and transferred to a computer. This study showed that the erosive capacity of different drinks, juices and foodstuffs is statisticaly significantly associated with their titratable acidity, pH values, phosphate and fluoride contents. A carbonated drink showed the highest significant decrease in surface microhardness followed by grapefruit juice, apple juice, and salad dressing (Lussi et al 1993).

4) Iodide Permeability Test (Ip)

The Iodide permeability test measures changes in the permeability of the surface of the teeth, and can detect very early stages of enamel demineralisation. It has been used as a method for measuring erosion as well as measuring caries in two studies (Zero et al 1990, Lussi et al 1993).

Both studies were experimental and used prepared enamel specimens of bovine (Zero et al 1990) or human (Lussi et al 1993) origin. After cleaning, iodide was applied to

windows on the prepared specimens for a given period, 3 minutes in one study, 20 minutes in the second. Remaining iodide was wiped away, and the surfaces cleaned with cleaning solution before covering with double-deionized water (DDW) for a 5 second period. The DDW was then analysed using an iodide specific electrode. Ip was determined at baseline and after the enamel window was exposed to a period of demineralisation. The difference between the two indicated the change in permeability.

5) Digital Image Analysis (DIA)

Digital image analysis has been found to improve accuracy and reliability, and to reduce time and labour requirements, but the equipment and programs are expensive. The surface to be examined is set in a fixed position and imaged by a video camera. A feature such as a ridge or other limit of eroded tissue is chosen as a threshold between different zones of attack that can be discerned, and its position is traced and stored, after which the area and the depth of the damage to the tooth enamel can be calculated, and statistical comparisons between different treatments can be performed. This method has been used for assessing erosion of rat molars (Mistry & Grenby 1993).

6) Scanning Electron Microscopy (SEM)

Scanning Electron Microscopy inspects changes in enamel surface ultrastructure which demonstrate the progression of erosion in prismatic and aprismatic enamel. It mimics the tooth surface and it is reproducible but as in the case of DIA it requires very expensive equipment and skilled operators.

SEM methods have been used in at least 3 investigations in which erosion was induced experimentally (Addy et al 1987, Rytomaa et al 1988 and Meurman et al 1990).

In all cases, specimens of enamel, either human or bovine were first exposed to erosive conditions including; various acids (nitric acid, sulphuric acid, citric acid, lactic acid, tannic acid and formic acid) and drinks including wine, cola, fruit juices and fruit based drinks, yoghurt (fruit), carbonated mineral water, beer, tea, coffee (with or without sugar), buttermilk and sports drinks, before their surfaces were sputter-coated with gold and examined using a Scanning Electron Microscope. Magnifications used have ranged from 30 to 7000 times.

Rytomaa reported distinct loss of enamel including disruption of enamel prism structures when teeth were exposed to cola beverage, orange beverages, sports drinks, diet cola beverage and orange juice but no abnormal surface alterations were observed in enamel treated with carbonated mineral water, beer, coffee (with or without sugar), yoghurt or buttermilk (Rytomaa et al 1988).

Smear layers were seen completely covering underlying tubules on the control portions, whereas portions exposed to acids showed loss of the smear layer and exposure of large numbers of tubules. Assessment of the surface appearance of the specimens was made from representative photomicrographs of each specimen. The scoring was based upon an observational grading of the number of tubules with 0 = no tubules visible to +++ = many tubules seen (Addy et al 1987).

Other studies using a replica impression technique have been reported recently. Impressions were taken of windows prepared on extracted teeth. The casting made up from the impressions was examined by SEM methods after gold sputtering. This experimental model is said to mimics the conditions at the tooth surface in vivo and to be highly reproducible (Millward et al 1995 & Teo et al 1997).

7) Use of Synthetic Hydroxyapatite powder/discs

To help overcome problems arising from the variability of extracted teeth and enamel samples of diverse provenance, the erosive potential of soft drink formulations has been determined using an enamel-like disc composed of ceramic (sintered) hydroxyapatite measuring weight loss gravimetrically before and after immersion in erosive solutions (Andon et al 1992). This has the advantage of reproducibility, but the method means that findings may not be directly applicable to tooth tissue.

8) Intra-oral Cariogenicity Test (ICT)

Testing using the Intra-oral cariogenicity test (ICT) has also been found to be useful in erosion research. Slabs of enamel are mounted in the human mouth in intraoral appliances and subjected to cariogenic or erosive conditions, after which demineralization can be recorded by mean of microradiography and changes in surface microhardness (Koulorides & Chien 1992).

9) Measurement of tooth wear using a Laser Profilometer

This is a novel method for measuring tooth wear in vivo using metal disks cemented to the palatal tooth surfaces of upper incisors, and impressions taken at 6-month intervals. Wear was estimated by scanning the impressions with a contacting laser profilometer and measuring a change in depth around the disk over a 6-month period, using fixed reference points on the metal disks (Bartlett et al 1997).

10) A model used to measure erosion in situ then in vitro

This is a controlled method that was devised to study erosion in situ in relation to a single agent (orange juice) over a relatively short period of time, and to compare this with erosion produced by the same method applied in vitro. An intra-oral appliance capable of retaining an enamel sample was used to retain a specimen of enamel in the mouth. It was found that this method was reproducible and accurate (West et al 1998). This is one of the first of its kind to model erosion in vivo by a single potential aetiological agent under highly controlled conditions.

11) Scanning Microradiography (SMR) and X-Ray Microtomography (XMT)

A number of other innovative and sophisticated techniques that should be capable of measuring erosive potential have been suggested. These include scanning microradiography (SMR) and x-ray microtomography (XMT).

In scanning microradiography (SMR), a thin section is stepped across a 15 μm diameter X-ray beam and the transmitted intensity measured at each point. This technique has permitted more accurate measurements of the spatial variation of the mineral concentration in sections of dentine and enamel than conventional photographic microradiography.

X-ray microtomography (XMT) can be carried out by adding an axis of rotation to the SMR apparatus. Using this method mineral concentrations, can be measured. This has advantages over the SMR in that superposition within the depth of the section and errors in determining its thickness are avoided. XMT studies of de- and remineralization

similar to those described for SMR (Elliott et al 1994). To date, these have not been utilised in erosion research.

Summary

The methods of measuring erosion used in vitro have often employed sophisticated technological techniques. They have allowed greater understanding of the processes of acid dissolution of hydroxyapatite, particularly in its early stages, and of the erosive potential of differing acids and dietary items. Many have a drawback in that they may not measure erosion that is equivalent to that found clinically when factors such as saliva may modify the process and where aetiological factors may act in ways that are not equivalent to experimental interventions. The methods are also not designed for use in large epidemiological studies.

4. Epidemiology of Erosion

4.1 Prevalence of Erosion and of Tooth Wear

Surveys showing the prevalence of erosion are relatively few in numbers. Many of the studies use different indices and different teeth in the assessment so making direct comparisons difficult. Additionally, many of the studies carried out appear to measure tooth wear and are not confined to erosion. Some details of studies of the prevalence of tooth wear are summarised in Table 2.14 (pages 90 - 91).

One of the earliest studies to include details of a population-based survey was that of Sognnaes et al in 1972. These workers had examined 10,000 extracted permanent teeth

from Southern California. Examination of all surfaces of each tooth was made with a binocular dissecting microscope for screening. Various lesions and restorations were grouped as: presence of some form of erosion; pattern of tissue loss; with or without other forms of pathology such as caries, calculus, or dental restoration.

No specific scoring system was used, only the presence/absence of a pattern of erosive-like lesions was noted. Sognnaes et al reported that 18% of the teeth had erosive lesions. Mandibular teeth had a higher frequency of erosion than maxillary teeth (21% as compared with 13%), with mandibular incisor teeth most commonly affected (28%) (Sognnaes et al 1972).

Since this report, studies have been carried out on historical material (Robb et al 1991) and in modern populations. Amongst the latter, investigations have been related to adults and to children (Xhonga & Valdmanis 1983, Lussi et al 1991, Smith & Robb 1996, Johansson et al 1996, Milosevic et al 1994, Bartlett et al 1998, Jones & Nunn 1995, Millward et al 1994 a, Millward et al 1994 b, O'Brien 1994, Hinds & Gregory1995).

4.1.1 Prevalence in historical material

The investigation of historical material employed 151 adult skulls, dating back to Roman and Anglo Saxon Britain. The wear index of Smith and Knight was used to assess tooth tissue loss. A control group was made up of 947 cases who formed part of a separate study to assess pathological tooth wear in a group of subjects attending the dentist in the south-east of England. Of the 151 skulls, 30 (20 %) showed evidence of extensive wear. Most of the skulls had evidence of severe wear on the lingual surfaces

of both upper and lower teeth. The site of the tooth surface loss led the authors to conclude that the causal factor was gastric regurgitation. This was very similar to patterns seen in the control group, where extensive tissue loss from the lingual surfaces had been linked to a specific cause. Occlusal wear was greater in the skulls than in the control group and became more marked with age. The authors thought that the coarser diet of the skull population may have contributed to this findings although it was not regarded as the primary cause (Robb et al 1991).

4.1.2 Prevalence in modern populations

I) Prevalence in adults

Amongst modern populations, in the United States, a survey of patients attending dental hospitals in Los Angeles and Boston purported to look specifically at the prevalence of erosion. Five hundred and twenty seven patients were included, their ages ranging from 14 to 88 years and including both males and females. All patients were examined and evaluated by one person at each location. The severity of erosion was graded as minor, moderate and severe; and as erosion occurring in the presence or absence of other pathology, such as caries, fillings and crowns. The pattern of erosion was considered as wedge, saucer, groove and atypical. Prevalence was found to vary by city and by tooth type. Approximately 25% of all teeth exhibited erosion but with a higher rate in Los Angeles than Boston (Xhonga & Valdmanis 1983). However, although the tissue loss was regarded as erosion, it has been pointed out that the illustrations contained in the paper suggested that many of these lesions were a result of abrasion rather than erosion (Nunn 1996).

In Europe, a random sample of Swiss adults was selected to examine the prevalence of dental erosion in Switzerland (Lussi et al 1991). Examinations of 391 people were carried out in their own homes using a scoring system modified from that of Linkosalo & Markkanen in 1985, which is based on an index described by Eccles & Jenkins in 1974 (described earlier see section 2.3.2). Each subject was examined for the presence and severity of erosion on all tooth surfaces (facial, lingual, and occlusal surfaces) except those of third molars. Of the sample, 197 were aged between 26 and 30, and 194 were between 46 and 50 years of age. Forty three percent of the older group and 30% of the younger group had erosion of occlusal surfaces involving dentine (grade 2), with an average of 3.9 and 3.2 teeth affected per subject respectively. Thirteen per cent of the older group and 8% of the younger group had one or more tooth affected with erosion of facial surfaces to the extent of involvement of dentine (grade 2). Six per cent of the older age group and 4 % of the younger age group showed slight lingual erosion on the maxillary anterior teeth. Only 2% of the older subjects (4 cases) had severe lingual erosion (grade 2) and two of these had a history of chronic vomiting. For the reminder of the subjects, there was a statistically significant relationship between observed erosion and dietary habits such as intake of fruit juices, citrus or other fruits (Lussi et al 1991).

The survey on adult patients included as controls for historical data was carried out to provide baseline data on the prevalence of tooth wear. This survey included 1007 patients with ages ranging from 15 to over 65 years old. TWI was used, but with the understanding that a degree of tooth wear is normal and progresses throughout life. Tooth wear which was acceptable in an older age group would not be so in younger patients. It was therefore necessary to designate threshold values of acceptable levels of

tooth wear for different age groups to reach realistic conclusions about the prevalence of unacceptable levels of tooth wear. Of the 1007 patients examined only 9 had completely unworn dentitions and 5% of the tooth surfaces examined had wear which exceeded the threshold values. Of the 15 to 26 year age group, 6% of tooth surfaces were worn to unacceptable degree. In the 56 to 65 year age group, wear was seen in 8% of surfaces and in those over 65 years age was 9% were worn to unacceptable degree (Smith & Robb 1996).

Studies of tooth wear have, most often, been carried out in westernised countries but there have been some investigations elsewhere. In Saudi Arabia, tooth wear in young adult Saudis has been the subject of more than one investigation. It has been suggested that the severity of tooth wear in Saudis significantly exceeds that found in similarly aged western populations. In one study in male Saudi military inductees, special reference was made to soft-drink consumption and dental erosion. A random selection of 95 individuals was included with an age range between 19 and 25 years. Grading of erosion was performed by using a modified version of the ordinal scale described by Eccles & Jenkins (1974). Incisal surfaces were excluded from the examination because of the difficulties in distinguishing between attrition and erosion of these surfaces. Only maxillary incisors and canines were graded and only buccal and lingual surfaces. Seventy seven percent of the teeth had suffered some degree of erosion. Lingual surfaces were significantly more affected than buccal, and central incisors showed significantly more erosion than lateral incisors and canines. A strong correlation was seen between the presence of dental erosion and a high level of consumption of cola-type soft drinks. Soft-drink consumption (250 litres per year) far exceeded that reported in western populations (Johansson et al 1996).

II) Prevalence in children

Investigations of the prevalence of erosion in children have to date been confined to the United Kingdom and have all been reported within the last decade. Studies have included permanent or primary teeth or both.

A random sample of 1035, 14 years old children from 10 schools in Liverpool was included in a study carried out in 1991. Examinations were carried out using dental mirrors and an intra oral fibre optic light tip. Four surfaces (cervical, buccal, occlusal/incisal and lingual) of every tooth were scored using the Tooth Wear Index (Milosevic et al 1994). Overall, thirty per cent of the children had exposed dentine, this was most often seen on the incisal edges and was evident more often in males. In addition to incisal wear, 80 (8%) children also had exposed dentine on occlusal and/or lingual surfaces. The occlusal surfaces of the first mandibular molars and the lingual aspects of the upper incisors were most often affected (Milosevic et al 1994).

More recently, a study of tooth wear in a sample of adolescents in London has been reported (Bartlett et al 1998). The study had the aim of determining the relationship between tooth wear, diet and gastro-oesophageal reflux. A cluster sample of 210 children 11 to14 years old were examined using the Smith and Knight tooth wear index. Salivary flow rate and buffering capacity, diet and symptoms of gastro-oesophageal reflux were also recorded for all subjects. Separate examiners were responsible for assessing tooth wear, salivary flow rate and buffering capacity, and diet and reflux histories on the same occasion.

Tooth wear of enamel was common, with 57% of subjects having erosion on more than ten teeth and a median 12% of surfaces affected per subject. Erosion of enamel was most common on the upper and lower central incisor teeth. However, erosion into

dentine was rare. No correlation was found between erosion and the intake of carbonated drinks, nor with salivary flow rate or buffering capacity. Adolescents with a history of regurgitation had a higher maxillary TWI compared with those who did not (Bartlett et al 1998).

III) Erosion and tooth wear in primary teeth

Erosion and/or tooth wear in primary teeth has been considered in at least 5 studies.

A study of oral health (including erosion of maxillary incisors) and social class in 3-year-old children was undertaken in East Cumbria in 1993. A random sample of 270 children was selected to take part, 135 of whom were finally included in the study. Palatal and buccal surfaces of the maxillary central and lateral incisors were examined for evidence of erosion and the type and extent of erosion was recorded. The criteria used in the National Survey of Child Dental Health carried out in 1993 and described above (Section 2.3.2) were employed for the assessment. All evidence of dental erosion was confined to the palatal aspects of the upper primary teeth, with only 2 children presenting with erosion of the buccal surfaces of their incisors. Almost one third, (29%), had one or more maxillary incisors affected by erosion. Involvement of both enamel and dentine was the most prevalent type of defect with 17% of children showing erosion in this category. It was noted that 12 children (9%) experienced erosion which extended for less than one third of the palatal surface, whilst for 21 children (15%), more than two thirds of the palatal surface was involved (Jones & Nunn 1995).

In a study reported the following year, 178 children, eighty boys and ninety-eight girls age 4 and 5 years old from the West Midlands had been investigated for erosion.

Children had come from five differing schools. These schools were selected because they had very clearly defined catchment areas of uniform socioeconomic background. Unlike the earlier survey, the classification of erosion used was based on the Tooth Wear Index of Smith and Knight, with some modifications. All teeth were assessed but incisal edges of primary incisor and canine teeth were excluded from this analysis. The children were classified into one of three groups:

1. No or mild erosion: no tooth score higher than 1
2. Moderate erosion: at least one tooth in the dentition scored 2
3. Severe erosion: at least one tooth in the dentition scored 3 or 4

Overall, nearly half the children showed some erosion, with the most commonly affected site being the palatal surfaces of maxillary incisors. Over 30% of these surfaces showed visible dentine, with almost half of these having scores of 3 and 4. The majority of tooth surfaces showed minor degrees of tooth tissue loss; confined to loss of enamel surface characteristics - score1 (Millward et al 1994 a).

A second investigation from the same area during the same year was set up to determine the severity and distribution of tooth wear in a selected group of children attending Birmingham Dental Hospital. The study involved 101 children attending the children's unit of the University of Birmingham Dental School and Hospital. Twenty of these children had been referred by general dental practitioners who had been particularly concerned about tooth tissue loss, but a further 81 were randomly selected patients. Their ages ranged from 4 to16 1/2 years and they included both males and females. The Tooth Wear Index of Smith and Knight was again used. Buccal, occlusal/incisal and lingual surfaces of each tooth present were examined and the children again classified into groups; with mild, moderate, and severe erosion. Evidence of tooth wear was found

in over 80% of maxillary incisor teeth, and 30% of the primary molar teeth had some dentine exposed. The palatal surfaces showed the most extensive tooth tissue loss attributable to erosion. There were 21 children who were regarded as having 'mild' erosion, 45 'moderate' and 35 'severe' erosion (Millward et al 1994 b).

As well as these smaller scale investigations, erosion has also been considered in two much larger surveys of dental health in children in the UK. National Surveys of Child Dental Health in the UK have been carried out every 10 years since 1973 and have included children aged from 5 to 15. The survey in 1993 included an assessment of dental erosion of maxillary incisor teeth for the first time. Results from the calibration exercise conducted during the dentist's training for the survey indicated that examiners found it difficult to agree in determining the presence of erosion of the enamel, so comparisons between countries on this basis alone may be suspect. The low levels of agreement between dentists in the case of enamel erosion need also to be borne in mind when considering the results of the survey. Erosion into dentine and the dental pulp may have been easier to identify.

Overall the results showed that over half (52%) of the 5 and 6 years old had evidence of erosion, and in nearly a quarter (24%), dentine was involved. Loss of tooth tissue was greatest on palatal surfaces of the incisors, with 52% of 5 years old affected, compared with only 18% presenting with buccal erosion.

In the permanent dentition, erosion was both less common and less severe than that of the primary incisors. Two per cent of seven years old were found to have some erosion on the buccal surfaces limited to enamel, rising to 12% of children age of 13 to 15. On the palatal surfaces of the permanent incisors the proportion of children with erosion rose gradually throughout the age range, from 7% of 6 years old to a maximum of 32%

among 14 years old, falling slightly to 27% among 15 years old. However, there was little erosion into dentine or pulp in permanent teeth (O'Brien 1994).

Erosion was also included in the survey of oral health carried out in conjunction with the National Diet and Nutrition Survey of 1 1/2 - 4 1/2 years old children. The study used the same criteria on erosion as in the National Child Dental Health Survey. Again, erosion confined to enamel was difficult to identify. Complete examination of the buccal surfaces were achieved for 1522 children and 1496 children had a complete examination for palatal erosion. Overall, 19% of children had erosion of the palatal surfaces of their primary incisors teeth and 10% had erosion affecting the buccal surface. Erosion into dentine or pulp, affected the palatal surface of the teeth of 8% of children and the buccal surfaces of 2%. The prevalence of erosion increased with age, with 3% of children aged 1 1/2 to 2 1/2 years found to have some palatal erosion into dentine or pulp compared with 13% of those aged 3 1/2 to 4 1/2 years (Hinds & Gregory 1995).

The oral health investigation of these pre-school children had accompanied a large diet and nutrition survey. Differences in relation to erosion were small. For example, 32% of 3 1/2 to 4 1/2 years old who consumed carbonated drinks (including low calorie carbonated drinks) had evidence of palatal surface erosion compared with 28% of the same age group who consumed such drinks less frequently. The equivalent data for buccal surface erosion were 19% and 12% respectively. There was some trend for a relationship between bedtime consumption of drinks and the prevalence of erosion, with 41% of 3 1/2 to 4 1/2 years old who consumed drinks containing non-milk extrinsic sugars (including: fruit juices, squashes and carbonated drinks) showing evidence of

palatal surface erosion compared with 30% of children who did not have drinks of this type at bed time (Gregory et al 1995). Differences failed to reach statistical significant and the authors concluded that they had been unable to find a relationship between dietary behaviour and erosion (Gregory et al 1995).

4.2 Relationship between Erosion and Social Class

The relationship between social class and erosion was investigated in three of the studies carried out in children in the UK.

In the study of erosion in permanent teeth carried out in Liverpool, there was an association between the prevalence of tooth wear and the area of the city where the school was located. The three schools with the lowest prevalence of occlusally and lingually exposed dentine were located in the more affluent areas of the city, while the schools in the deprived areas showed a higher prevalence of tooth wear as a whole (Milosevic et al 1994).

There were also distinct social class differences seen in the prevalence of erosion affecting enamel and dentine in the study of 3 years old carried out in East Cumbria. As before, children from the higher social class families (I and II) recorded the lowest prevalence at 5% compared with 22, 24 and 10% for social classes III, IV and V, and the unclassified group, respectively (Jones & Nunn 1995).

In contrast to findings in both of these two studies, there was a positive correlation between socio-economic group and the prevalence of erosion in the study of 4-5 years old in the West Midlands, with the children from the low socio-economic groups having less erosion. In this investigation 19% of children in high socio-economic groups had

severe erosion (surfaces scoring 3 or 4 on the Tooth Wear Index) compared with only 4% of children from lower socio-economic backgrounds (Millward et al 1994 a).

Summary

Loss of tooth tissue as a result of wear is increasingly being reported in the literature. A high prevalence of erosion in adolescents and in children has been reported in the United Kingdom but very little data is available from other countries.

In all studies the most commonly affected site was the palatal surfaces of the upper incisors. The relationship between erosion and socio-economic status is not yet clear. Studies have been largely confined to the UK and systems of social classification used may not be appropriate if studies are to be carried out in other parts of the world. In addition, oral health status may not bear the same relationship to social class since determinants such as dietary patterns may well differ.

Table 2.14 **Summary of prevalence studies of tooth wear**

Author & year	Age of the subjects	Dentition examined	Number of subjects	Index used	Prevalence	Associations seen
Sognnaes et al 1972	Adults	P	10,000 extracted teeth	——	18% (1700 teeth) with erosion, with mandibualr incisors most commonly affected (28%)	–
Xhonga & Valdmanis 1983	14-88	P	527	——	25% had erosion	Result of abrasion rather than erosion
Robb et al 1991	Adult skulls	P	151 skulls	TWI	19.9% (30) had extensive wear (mostly with severe wear at the lingual surfaces of both upper and lower teeth	Gastric regurgitation
Lussi et al 1991	26-30 46-50	P (all tooth surfaces)	391	Modified scoring system by Linkosalo &Markkanen	**Occlusal** 29.9% of the younger gp 42.6% of the older gp with dentine involvement (grade2) **Facial** 7.7%of the younger gp 13.2%of the older gp with dentine involvement (grade2) **Lingual** 3.6%of the younger gp 6.1%of the older gp with slight lingual erosion on the maxillary anterior teeth 2% of the older gp with severe lingual erosion(grade2)	Dietary habits Chronic vomiting
Johannson et al 1996	19-25	P	95	Modified Eccles	77% of maxillary incisors and canine had evidence of erosion (28% with pronounced erosion)	–
Smith &Robb 1996	15-26 56-65 >65	P	1007	TWI	15-26yr old 5.73% tooth surface wear 56-65yr old 8.19% tooth surface wear >65yr old 8.84% tooth surface wear	–
Milosevic et al 1994	14	P (all tooth surfaces)	1035	TWI	all the children exhibited some tooth wear(score≥1) 30% (307) had exposed dentine incisally 8% (80) had exposed dentine occlusally/lingually	Level of social deprivation

Continued

Author & year	Age of the subjects	Dentition examined	Number of subjects	Index used	Prevalence	Associations seen
Jones&Nunn 1995	3	p (palatal & buccal of maxillary incisors)	135	Modified TWI	28.9%had one or more maxillary incisors affected 17% with both enamel & dentine involvement all dental erosion was on the palatal with only 2 cases on the buccal surface	social class
O'Brien 1994	5-15	Both (P + p) (palatal & buccal of maxillary incisors)	17061	Modified TWI	5-6 yr 52% with erosion on their primary incisors, 24% with dentine involvement. 11 yr and over 30% with palatal erosion on upper permanent incisors, 2%with dentine involvement	–
Hinds & Gregory 1995	1.5-4.5	p (palatal & buccal of maxillary incisors)	1496-1522	Modified TWI	19%with erosion on the palatal surfaces, 8% with dentine involvement. 10%with erosion on the buccal surfaces, 2% with dentine involvement.	Dietary behaviour
Millward et al 1994	4-5	p (all tooth surfaces)	178	Modified TWI	50% of the children had erosion most commonly on the palatal surfaces of maxillary incisors over 30%with dentine involvement.	Socioeconomic
Millward et al 1994	4-16.5	Both (P + p) (all tooth surfaces)	101	Modified TWI	80% of maxillary incisors had evidence of tooth wear, mostly on the palatal surfaces. 30%primary molars with dentine exposed.	Dietary constituents
Bartlett et al 1998	11-14	P	210	TWI	57% having erosion on more than ten teeth with a median of 12% of surfaces affected for a subject, mostly into enamel. Dentine involvement was rare.	Relationship with gastro-oesophageal reflux

Codes Used:

P Permanent teeth
p primary teeth
TWI Tooth Wear Index

5. Oral Health in Children and Social Classification in Saudi Arabia

5.1 Oral Health in Children in Saudi Arabia

There have been few studies carried out on the caries prevalence of children in Saudi Arabia and none would appear to have been yet reported on the presence of erosion. Studies that have been carried out have indicated that the prevalence of caries is increasing. Studies within the last 10 years suggest a prevalence between 68 and 87% amongst children (Al-Shammary et al 1990, Al-Kateeb et al 1991, Al-Amoudi et al 1996, Al-Mohammadi et al 1997).

Rampant caries, (defined as occurring when two or more primary maxillary incisors have caries affecting buccal or palatal surfaces) has also been reported to have a high prevalence in Saudi Arabia. In one study, 43% of a group of children from one city in the central province were reported to have rampant caries (Wyne et al 1995).

This high and increasing level of caries amongst children in Saudi Arabia has been related to determinants which include improper dietary habits, poor oral hygiene, a lack of dental awareness and education, and inadequate quality of dental treatment provided (Al-Amoudi et al 1996). Social factors are known to have a strong relationship to caries prevalence and severity and may also be important in Saudi Arabia.

- **Dietary habits**

In Saudi Arabia, both modern and traditional diets contain considerable amounts of sugar. Parents start giving sweet solids to the children at an early age. A high carbohydrate diet including large amounts of bakery products is also thought to be an important part of the Saudi culture (Wyne et al 1995).

Rampant caries has been particularly associated with nursing bottle contents which have sweetening agents added to them and to prolonged sucking of sweetened comforters (Winter 1966).

Adenubi (1982) reported that the main aetiological factors of rampant caries were the frequent use of sugar containing food and specially the consumption of soft drinks from an infant feeding bottle. Pure fruit juices marketed for consumption by infants, have also been shown to have pH values below the critical pH for the dissolution of enamel in erosion (Smith & Shaw 1987). A high proportion of a sample of pre-school children with a high dmft in Riyadh (51 child out of 68) were using canned soft drinks and packed fruit juices (Wyne and Khan 1995).

- **Poor oral hygiene**

It is usually recommended to parents that the tooth cleaning should start as soon as first tooth erupts. In Saudi, brushing practices were found to start around 34 months. This was considered very late compared with present-day recommendations (Wyne et al 1995).

- **Dental awareness, education and treatment needs**

The treatment need for dental caries is very high in Saudi. There has been little tradition of regular care or of parents seeking routine dental check ups for their children (Wyne & Khan 1995). Many patients seek treatment only when their child is in pain. In some developed countries with a high level of dental awareness this may be regarded as dental neglect on the part of the parent for failing to bring their children early for treatment but in Saudi Arabia it may be at least as much a result of poor accessibility of appropriate services (Al-Amoudi et al 1996).

The population of Saudi Arabia is thought to be in the region of 18.8 million. In 1996 there were reported to be a total of 1237 dentist working in government funded centres in addition to the dental care provided by the private sector (Ministry of Health, 1996). The government's philosophy is that high quality dental care should be available for the entire population free of charge, regardless of social standing or of educational level. This policy functions effectively in the cities, but not in rural areas, where the distribution of personnel is more uneven. Until relatively recently, there was an acute shortage of dental personnel in the Kingdom, it was reported that in 1986 there had been only 850 dentists in the kingdom, giving an approximate dentist to population ratio of 1: 9,411 (Guile and Al- Shammary 1987). In 1996 there were 2999 dentist with a ratio of 1: 6118 (Ministry of Health, 1996). Access to services in the major cities may now be improved but there may well be a shortage of accessible dental services in other parts of the kingdom. To try to overcome this difficulty there are now 150 mobile dental clinics used to provide service to residents of remote villages.

- **Socio-economic factors**

At least three studies in the Kingdom of Saudi Arabia have shown a higher caries prevalence in children from lower socio-economic groups (Al-Khateeb et al 1991, Wyne et al 1995, Al-Mohammadi et al 1997). The level of dental caries in Saudi was also found to be higher amongst urban than in rural populations. This may be related to different life styles, with rural children having less access to refined carbohydrates than their urban equivalents (Al-Shammery et al 1990). Rampant caries has also been found to be higher (43%) in children with a middle socio-economic class father and less educated mother (Wyne et al 1995).

5.2 Systems used for social classification in the Middle East and in Saudi Arabia

In all societies members may be classified into various social strata or layers. Systems are hierarchical and allow generalisations about lifestyles, behaviour, and attitudes of others, based on the pattern for that group as a whole. Not everyone from a social class will share the same lifestyle, but the difference between those from the various classes are often greater than those within classes. One commonly used set of social classes includes lower class, working class, middle class and upper class (Petersen 1997).

Social class may influence disease in a wide variety of ways. Differences in class may reflect differences in life style (including diet), in behaviour and attitudes/ knowledge.

It is suggested for example that a less healthy diet is consumed by those in the lower social class leading to more disease in consequence.

There are numerous methods for dividing the population into social classes. One generally used system is the Registrar General's classification of occupations, whereby people are grouped into 6 strata according to the occupation of the head of household. More recently, measures of deprivation have been introduced. These include, the Registrar General's Social classification, JARMAN, ACORN and TOWNSEND. These are based on place of residence either in terms of area (eg TOWNSEND) or type of housing (eg ACORN).

All of these systems have been developed and used in the U.K. They are likely to be much less applicable in countries of very dissimilar culture, such as the Middle East.

5.2.1 Class structure in the Middle East

Systems used in the past for studies of oral health in Middle Eastern countries include one from Amman and three from Saudi Arabia.

About 1.4 million Jordanians live and work in Amman, which is the centre of the country's political, economic and social life. In the method used to define social class in Amman, a structure was derived from a survey of employment, unemployment, and poverty which was carried out by the department of Statistics towards the end of 1991.

A four-class typology was used referring to upper, middle, working, and dispossessed classes, with a degree of variation within each class.

The upper class

The upper class comprised domestic capital owners (industrial, commercial and trading) senior executives, and top state managers.

The middle class

The middle class included segments such as professionals, petty bourgeois (or traditional middle class), and executive or administrative positions in business or in government agencies.

Working class

The working class consists of ordinary people who do all the routine jobs, typically involving clerical and manual wage labour in public enterprises and private industries and services.

Dispossessed class

The dispossessed class includes people who cannot find regular jobs or who work irregularly but are frequently unemployed for long periods of time. This includes some divorced women with very low-paid jobs and some retired people.

5.2.2 Class structure in Saudi Arabia

The population of Saudi Arabia has been considered as being made up of 3 clearly stratified groups; urban, rural and Bedouin, whose life-style has been defined in relation to their traditions, cultural and social pattern. Individual variation within each group and within the person's own group may also be observed in relation to social class in terms of occupation and education. In recent years, the fabric of life has altered, poor living conditions, health services and sanitary conditions have been largely replaced by much higher standards of living and better health care.

In phase 1 of a large recent Oral Health Survey in Saudi Arabia, electricity company listings were used in the absence of any better sampling method. By the time of phase 2, the Ministry of Municipalities and Rural Areas had published detailed and well-organised maps of the country's urban areas. These maps included socio-economic divisions, density of the population, and many other items of information. After reviewing the maps, two types of stratification were selected for sampling strategy. These were: a) housing density, divided into low, medium and high density, and b) quality of housing, divided into good, fair and poor housing. The combination of these categories provided a maximum of nine strata for each urban area. For the schoolchildren included in the survey, school selection was based on the assumption that Saudi parents send their children to a school near their residences (Al-Shammary et

al 1991, Al-Shammary et al 1994). By being related to housing density and quality, this system resembles ACORN.

In another recent survey children in urban areas only were classified according to socio-economic status. Socio-economic status (SES) was grouped into three levels, high, middle, and low, using three items of information on each child; residency, parents' income and parents' level of education. Each of these was classified into three levels, so that a child could have a score of one for each item (residency, income and education) giving a combined score of 3, or a maximum combined score of 9 (3*3). The following criteria were used:

- **Place of residency**: In each city, three levels of area of residency, high class, middle class, and low class areas, were determined by the school authorities and health authorities (primary health care centres). These were given a score of 1 for low class, the middle class 2, and the high class areas a score of 3.
- **Family income:** The Directorate of Census and Information at the Ministry of Finance was consulted regarding classification of the incomes of the Saudi population. Per capita monthly income was determined by the questionnaire, completed by one of the parents. This was divided into three categories:

  1,000-5,000 (SR) (low income - a score of 1)

  5,000-10,000 (SR) (middle income - a score of 2)

  10,000 (SR) and over (high income - a score of 3)

- **Parents' level of education**: The educational qualifications of the parents were considered:

  -The lowest level of education included those unable to read and write, and those with reading and writing at primary school level only - score 1.

  -The middle level of education were those who had attended Secondary school and High School - score 2.

  -The high level of education included College and Postgraduate level-score of 3.

The calculation of child's socio-economic status (SES) level was by summation of the suitable scores of each component. Low level of SES was between 3-5, middle level was between 6-7, and high level was between 8-9 (Al-Mohammadi 1995).

In another much smaller study related directly to oral health, social classification was based on parent's occupation, education and income (Al-Ghanim 1996). According to the government salaries, parent's income was divided into five categories to reflect their economic status as follows:

Category 1	Low	equal or less than SR 2,000
Category 2	Middle	between > SR 2,000 to < SR 4,000
Category 3	Upper Middle	> SR 4,000 to < SR 8,000
Category 4	High	> SR 8,000 to < SR 12,000
Category 5	Upper High	> SR 12,000

This system includes elements common to those widely used in the UK and elsewhere, but requires more information about each subject which may make it more cumbersome in use.

Summary

It may be concluded that oral health amongst children in Saudi Arabia in terms of caries is poor. Prevalence of caries and of rampant caries are both high and may be increasing. This deterioration is thought to relate to poor dietary habits and oral hygiene practices and also to low levels of dental awareness amongst parents This may be partly because access to oral health care services has been limited up until relatively recently. As in other countries oral health in children has been related to social class.

CHAPTER THREE

MATERIALS AND METHOD

3.1 Study of exfoliated and extracted teeth

The study to determine validity of the index for erosion was based on an investigation of extracted and exfoliated teeth.

3.1.1 Sample of teeth

Exfoliated and extracted primary teeth were collected from child patients attending clinics in Saudi Arabia, the Eastman Dental Hospital or Community Dental Clinics in North London. Sound teeth, teeth with visually obvious erosion and teeth with early caries were included but teeth with extensive caries, restorations or fractures were excluded. Teeth were stored in formalin solution during the investigation.

A total of 100 primary teeth were collected, 41 of which were suitable. This total included 19 maxillary central incisors, 14 lateral incisors, and 8 canines.

Assessment of the teeth included the following three stages:

1- Preliminary visual inspection.

2- Photographic assessment.

3- Examination of sectioned teeth.

3.1.2 Preliminary visual inspection

After drying with a cotton gauze napkin each tooth was examined visually under ambient lighting conditions and without magnification. The appearance was described briefly in words and the tooth was then scored as to the extent of tissue loss, using the

scoring criteria shown in Table 3.1. Scoring was related to tooth wear. For the purposes of this inspection no attempt was made to distinguish between wear resulting from erosion, attrition or abrasion. Scoring was repeated after a 2 day interval.

Table 3.1 **The Scoring System**

0	No evidence of tooth wear
1	Tooth wear into enamel
2	Tooth wear into dentine
3	Tooth wear into pulp

3.1.3 Photographic assessment

The photographic set up used comprised an Olympus 101camera with Elicar 90 mm lens, T10 ring flash at fixed power and T power source. Films were Kodachrome 64 KR 135-36 P films providing colour transparencies.

Teeth were mounted in soft wax and two photographs were taken for each, at a fixed magnification of 1:1, one view from the palatal and the second from the labial aspect (Figure 1). Films were developed by Kodak Ltd (P.O Box 2, Deer Park Road, Wimbledon, London SW19 3 UG).

Colour transparencies were projected onto a white screen and assessed using standardised conditions including a fixed projector / screen distance and the viewer seated at a single fixed point for all the readings.

The photographic appearance was described as normal or showing wear. The presence of attrition, erosion, or both, and the surface(s) affected were recorded, as was the extent of tooth tissue loss.

The criteria employed at the visual inspection (Table 3.1) were then used to score the photographs. Transparencies were scored twice with a 2 day intervals to check reproducibility of the photographic assessment.

3.1.4 Examination of sectioned teeth

Preparation for histology

A single ground section from each tooth was prepared to view under the microscope as follows:

a) Each tooth was mounted using Impression compound green wax before being placed on the EXACT Saw machine (band saw) to prepare the initial slice. The tooth was cut sagittally in the long axis of the tooth and at right angles to the incisal plane so as to provide a section from at or close to the midline. The cut was made as close as possible to the midline because it was believed likely that any tissue loss, if present, would involve the midline.

b) Using an abrasive stone each slice was polished manually to obtain a thin section (approximately 20-30 μm) suitable for examination.

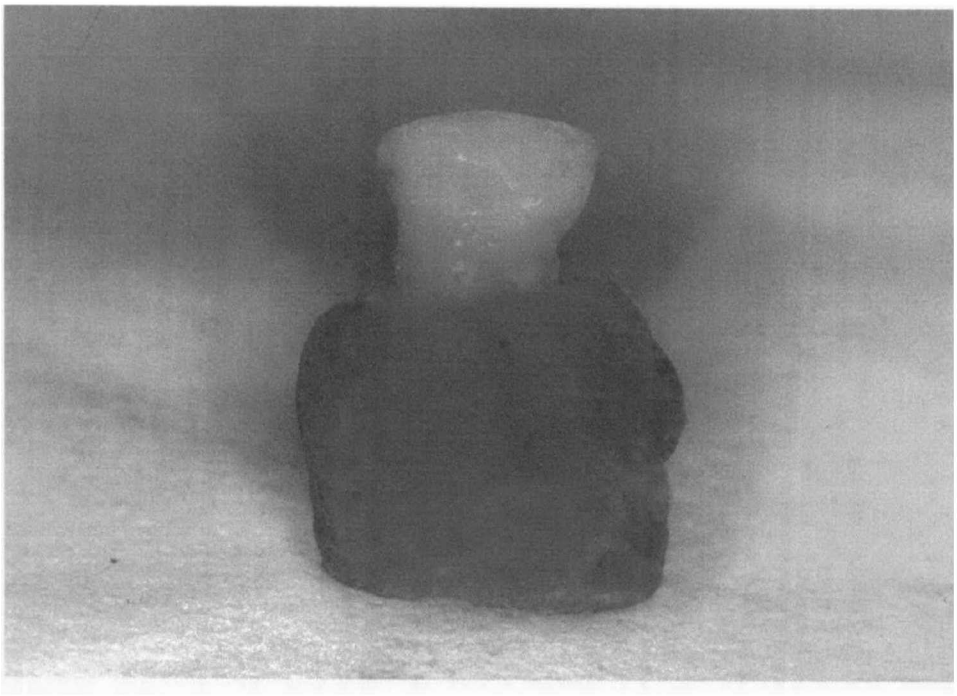
c) After polishing, sections were cleaned in alcohol for up to 12 hours for dehydration purposes and then in Xylene for a period of 2-3 hours.

d) Sections were then mounted onto a glass slide in a water based media.

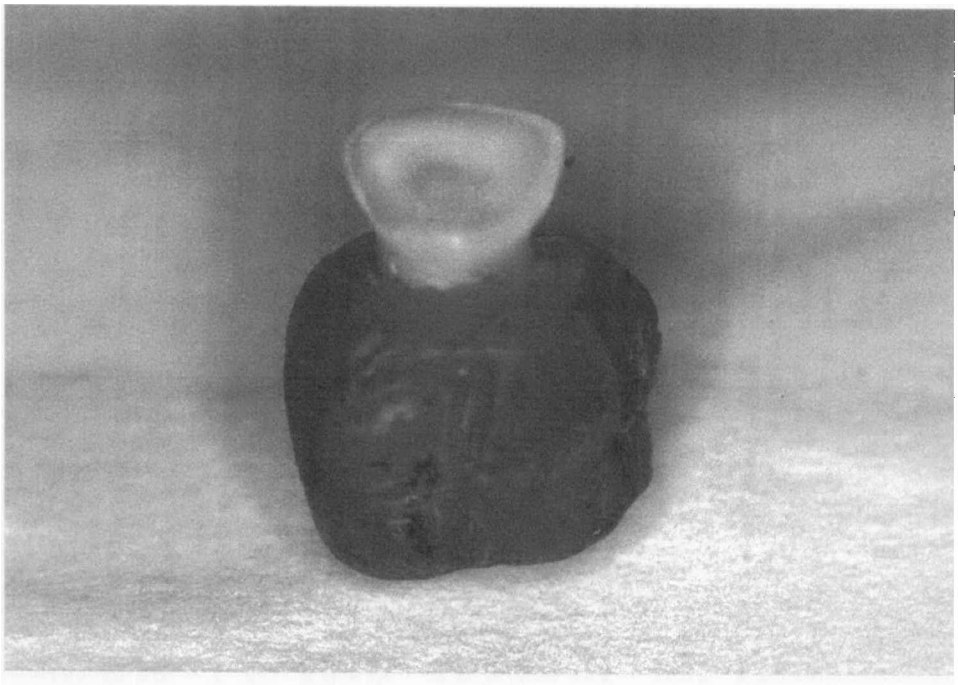
After preparation, sections were viewed using a polarised light microscope (Figure 2 shows the stages in preparation of section for microscopic assessment).

The scoring criteria shown in Table 3.1 were again used to assess the extent of tissue loss. Sections were examined twice with a 2 week intervals to check for reproducibility of assessment.

Results from the preliminary examination, photographic assessment and assessment of sections for the 41 teeth are shown in chapter 4.

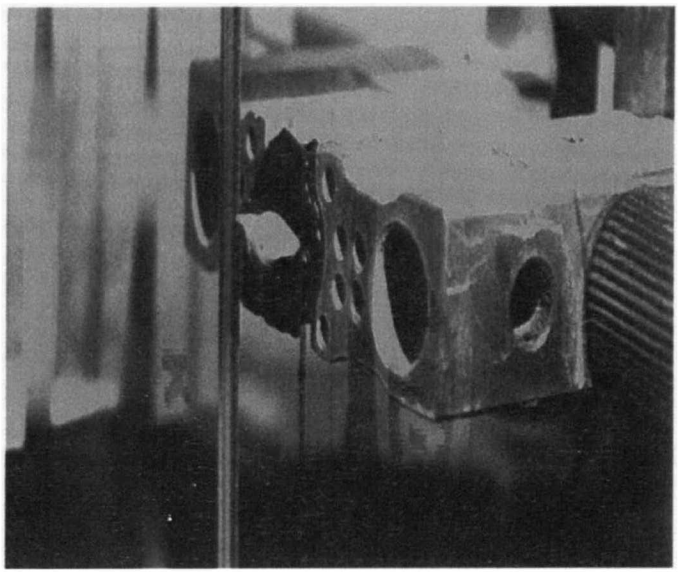


a) Labial view

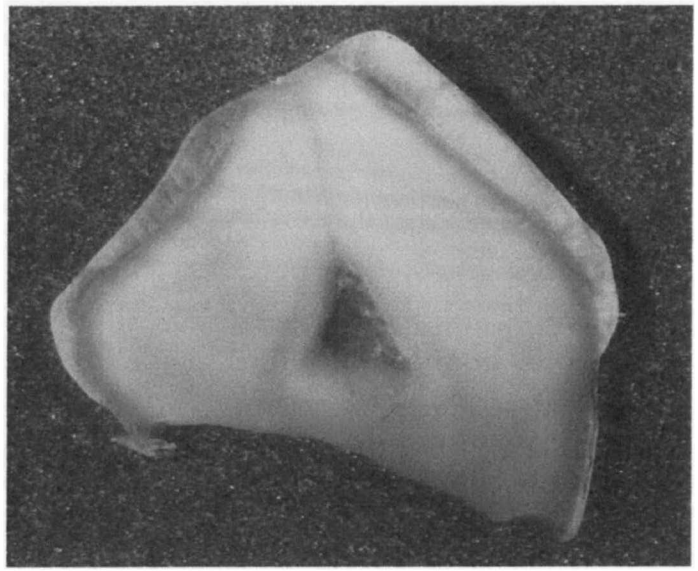


b) Palatal view

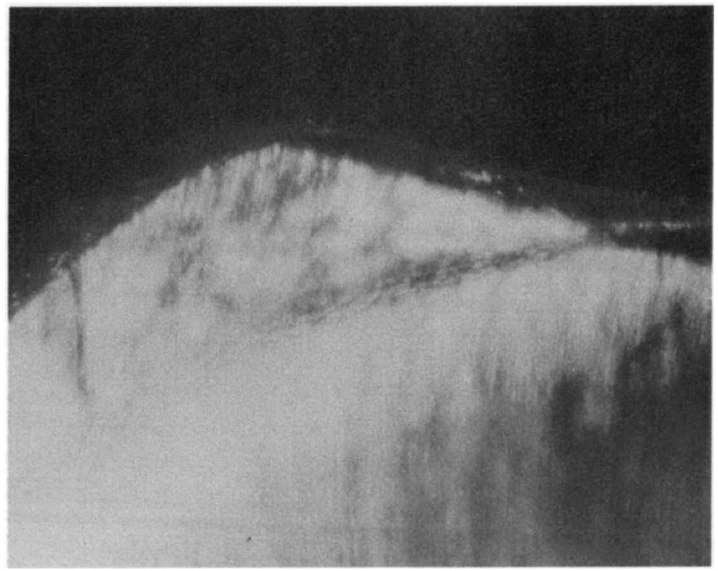
Figure 1:**Photograph of an extracted primary incisor tooth mounted in wax for photographic assessment**



a) Tooth mounted ready for sectioning using Exact diamond saw



b) Section prepared from primary incisor tooth



c) Section viewed using polarised light microscope

Figure 2: **Stages in preparation of section for microscopic assessment**

3.2 The Survey of kindergarten children in Jeddah

Approval for the study was sought from the 'Ministry of Higher Education' and through the 'President General for Girls Education Schools' office (Appendix 4). After permission was obtained from these authorities, schools were then approached individually to gain their agreement.

3.2.1 Sample selection

Sampling was carried out to provide a sample of one thousand pre-school Saudi children (age 2 to 5) attending kindergarten schools, Jeddah city in the Western Province of the Kingdom of Saudi Arabia.

The Saudi population in this region include Saudis of Yemini or Hadrami descent, as well as people of Egyptian, Lebanese, Syrian, Palestinian or other origin. There is a high incidence of mixed marriage in the region, with many children being of mixed origin. Non-Saudi children were all Arabic speaking and had lived in the kingdom through out their lives.

To select the sample, a list of all kindergarten schools in the city was obtained from the Department of Education of the Western Region of Saudi Arabia. The schools were then divided into two groups according to funding sources (private or public) and were also considered by area of the city (north, south, east and west).

Of the 152 schools listed, 20 were public schools; their rolls included a total of 2621 children. The remaining 132 were private schools attended by a total of 11,317 children

during the year 1997-1998 (personal communication with the Department of Education of the Western Region of Saudi Arabia).

The sample was designed to include 400 children from public schools (100 from each area of the city) and 600 children from private schools (150 from each area). These numbers were designed to allow estimation of the effect of school type attended and provide a reasonable representation of the children in the city.

A total of 17 primary schools (6 public and 11 private) were selected from the four geographic areas of the city (north, south, east and west). Sixteen schools agreed to take part, one private school declined to do so.

All 4 - 5 years old children attending the selected schools were eligible to take part. Letters were sent to parents through the schools explaining the purpose of the present study, requesting consent to their child being examined and photographed, and asking them to complete a short questionnaire.

The study included a clinical examination, photographs of the upper incisor teeth and a questionnaire to parents.

3.2.2 Clinical examination

Children were examined in schools for the presence of caries, rampant caries and erosion. Each child was dentally examined before two photographs of upper incisor teeth were taken.

Clinical examination was carried out under standardised lighting conditions using a Daray light (dental model order no. SL400/222 with "G"clamp) used at the brighter of the two settings. Each child was examined supine with the examiner seated behind the child (Figure 3). The examiner worked with a trained recorder. Teeth and surfaces were examined in a standard order and status recorded. Diagnosis was visual with a plane mouth mirror used to assist visibility and cotton rolls employed to remove any plaque or debris. A pair of sterile gloves and a set of fresh sterilised instruments were used for each subject. All teeth and surfaces were examined for caries. Examination for erosion was confined to primary maxillary incisors.

Method of collecting data

Findings at examination were recorded using the scoring form shown in (Appendix 1).

Criteria for diagnosis of caries

Caries were diagnosed and scored using the BASCD criteria and scoring system.

These are summarised in Table 3.2.

Table 3.2 **Scores and criteria for diagnosis of caries**

(Pitts et al 1997)

Score	Criteria and Diagnosis
0 Present and Sound	A surface is recorded as sound if it shows no evidence of treated or untreated clinical caries at the "caries into dentine" diagnostic threshold. The stages of caries that precede cavitation are excluded. Thus surfaces with the following defects, in the absence of other positive criteria, should be coded as sound: -white or chalky spots; -discoloured or rough spots; -stained pits or fissures in the enamel that are not associated with a carious lesion into dentine; -dark, shiny, hard, pitted areas of enamel in a tooth showing signs of moderate to severe fluorosis or other developmental defect. All questionable lesions are coded as 0.
1 Caries lesion	Arrested dentinal caries.
2 Caries lesion	Caries into dentine which is restorable.
3 Caries lesion	Caries into the pulp requiring extraction, pulp or root canal treatment.
4 Filled and Decayed	A surface which has a filling and a carious lesion will fall into this category unless the carious lesion can be coded as "for extraction or RCT".
5 Filled	Surfaces containing a permanent restoration of any material are coded under this category if otherwise sound.
$ Sealant restoration	Sealant code is used only if the surface contains evidence of sealant. All occlusal, buccal, and lingual surfaces containing, in the opinion of the examiner, some type of fissure sealant, but where no evidence of a defined cavity margin can be seen are coded here.
6 Missing due to caries	Surfaces are coded as missing if the tooth, of which they are a part, has been extracted because it was carious. Missing deciduous canine and deciduous molars are included in this category but missing deciduous incisors are not counted and are coded as permanent teeth, unerupted (code 8).
8 Unerupted	Surfaces are regarded as unerupted if the tooth, of which are a part, has not erupted into the mouth. This includes congenitally absent teeth or teeth missing for reason unknown.

Rampant caries

Rampant caries was defined as occurring when caries affected smooth surfaces of two or more maxillary incisor teeth (Winter 1971, Holt et al 1982).

Criteria for diagnosis of erosion

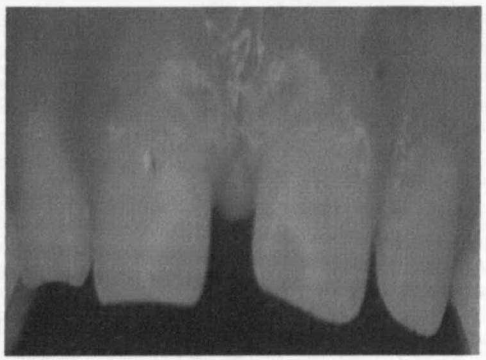
Each maxillary incisor tooth was scored using the scoring system and criteria tested in the first part of the study and shown in Table 3.3 and Figure 4.

Table 3.3 **The scoring system and criteria used for diagnosis of erosion**

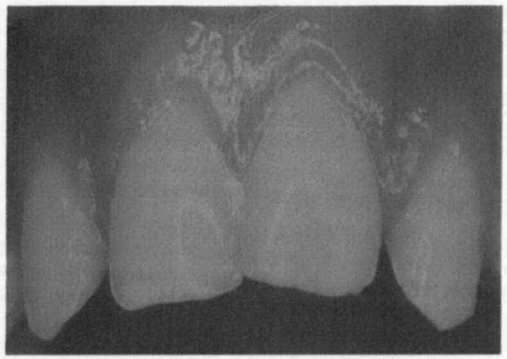
Score	Criteria	Description
0	Normal, no evidence tooth wear	No loss of enamel surface features, no change of contour.
1	Tooth wear into enamel	Loss of enamel surface features giving a smooth glazed shiny appearance. Relatively wide shallow concavities on enamel, dentine is not involved. Increased translucency of the tooth due to loss of enamel thickness. Evidence of "rimming" around the cervical margins.
2	Tooth wear into dentine	Extensive loss of enamel with dentine involvement. Exposure of dentine and/or secondary dentine. Distinct evidence of "rimming" around the cervical margins.
3	Tooth wear into pulp	Extensive loss of enamel and dentine with pulp exposure.
9	Cannot be assessed	Extensive caries, large restoration, fractured teeth, missing teeth.

Wear for all surfaces was noted but, for the purposes of the study and as in previous surveys of erosion in primary teeth (O'Brien 1994, Hinds & Gregory 1995, Millward et al 1994 a) only that affecting palatal and/or buccal surfaces was scored as erosion, wear confined to incisal surfaces was considered as being a result of attrition and was excluded from the analysis.

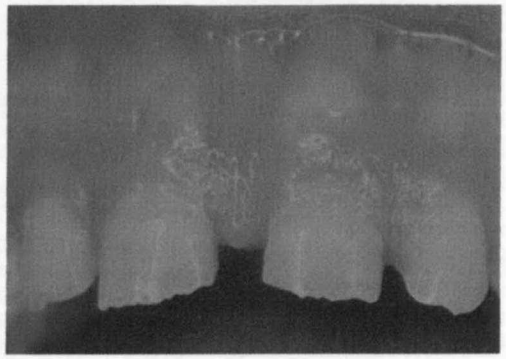
Figure 3: **Position of child, examiner seated behind child's head and recorder at clinical examination in kindergarten schools**



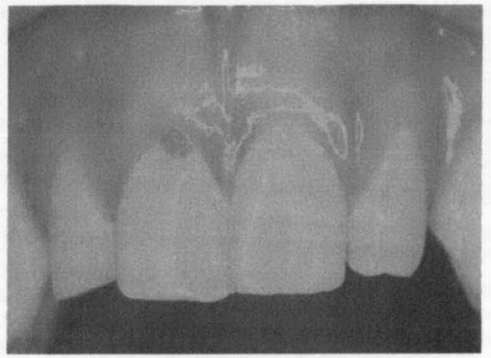
Labial surface score 0



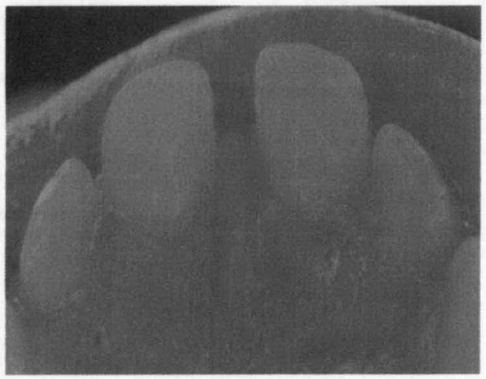
Labial surface score 0



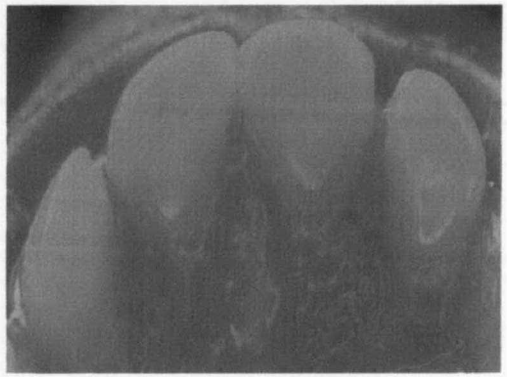
Labial surface score 0



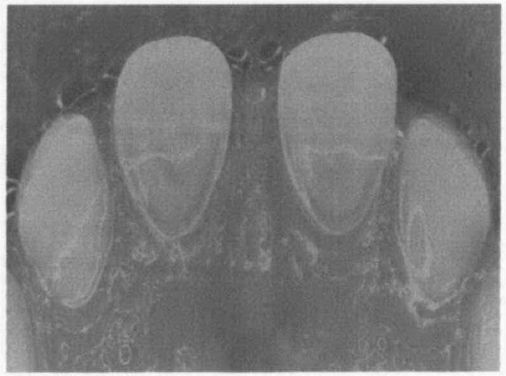
Labial surface score 0



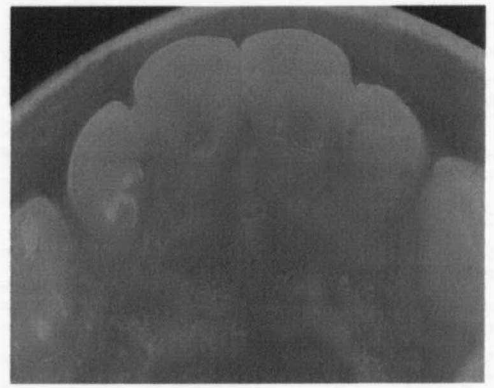
Palatal surface score 0



Palatal surface score 1



Palatal surface score 2



Palatal surface score 3

***Figure 4*: Index Used at Clinical Examination**

Training and calibration

The examiner was trained and familiarised with the examination method and the diagnostic criteria. Calibration was carried out prior to the study.

Inter-examiner

The clinical examiner (MAM) was calibrated in scoring for caries with an experienced examiner (RDH) in a series of 30 repeat examinations of children attending two kindergartens in Jeddah. The estimated kappa value for surfaces diagnosed as carious was 0.85.

Intra-examiner

Intra-examiner reproducibility of caries, rampant caries and erosion diagnosed at clinical examination was tested through repeat examination by the researcher on two occasions separated by two weeks, of 30 children. This yielded a kappa value of 0.96 for surfaces diagnosed as carious, and a kappa value of 0.92 for surfaces diagnosed as showing erosion.

3.2.3 Photography

Following the clinical examination for caries, rampant caries and erosion, photographs were taken of the upper incisor teeth. Two photographs were taken, one of the labial and one of the palatal surfaces of maxillary primary incisors for each child. Palatal views were taken using a polished steel photographic dental reflector (small size). The photographic equipment used was a Nikon F-601 camera with an Elicar 90 mm macro lens. This was used with a SUNPAK Auto DX12R Ring Flash at fixed power and with

T power source. Films were Kodachrome 64 KR 135-36 P films providing colour transparencies. Photographs were taken at magnification of 1:1, as close to a 30 degree angle from the labial surface as possible. Films were developed by Kodak Ltd (P.O Box 2, Deer Park Road, Wimbledon, London, SW19 3 UG). All clinical examinations and photography were carried out within a 3 month period between 1st September and 30th November 1998.

3.3 Questionnaire Study

For each child a questionnaire was supplied to parents. The questionnaire included questions modified from those used in two previous studies of pre-school children (Hinds & Gregory 1995, Holt et al 1996). A copy is included in (Appendix 2).

General information was sought on the child's age and gender, information was also sought about any chronic illness and medication taken by the child.

Socio-economic questions included parental occupation and education. The classification of occupation used was based on that utilised in the Oral Health Survey of Saudi Arabia in 1991 (Al-Shammary et al 1991) and was analogous to the Registrar-General's Classification of Occupations (Beal 1996). Higher professionals included doctors, professors, architects and businessmen and professionals included managers and teachers. Middle class occupations included governmental, private and self employed and skilled workers. Those classified as having unskilled and other occupations included military personnel, trade, students, the unemployed and those not indicating any occupation.

Dietary information sought included:

1. Infant feeding practices.

2. Past and current intake of drinks including fruit juices, diluted fruit syrups, herbal drinks and carbonated drinks.

3. Current frequency of selected foods, particularly fruit consumption.

4. Past and current use of sweetened comforters.

Questions were included about the age at which the child's teeth were brushed, frequency of brushing, with or with out assistance and type of toothpaste used.

The questionnaire was translated into Arabic before being tested in the pilot study. Minor adjustments to wording were made before the main study. A copy is included in (Appendix 3).

Questionnaires were distributed to the parents of the children by the school to be completed before the examination was carried out. The examiner was unaware of the responses to questions at the time of examination.

3.4 Statistical Analysis

All data were collected and entered into the SPSS program for analysis. Both descriptive and analytic approaches were used in the data analysis. Tests of the association between erosion and/or caries and single variables were carried out using Chi square test. A p-value of less than 0.05 was considered statistically significant. A non parametric test (Mann Whitney U test) was used to compare mean dmft and dmfs values.

For comparison of the sample proportions, standard normal deviation (SND) was estimated together with 95% confidence intervals. Multi-variate analysis was carried out using logistic regression analysis for the outcomes of erosion, caries and rampant caries.

3.5 The Pilot Study

The methodology used (including clinical examination, photography and questionnaire) was tested through a pilot study carried out before starting the survey. This also allowed testing of data handling and questionnaire and sample size estimation. Thirty children in two selected schools were included in the pilot study (one of these schools was re-visited as part of the main study).

CHAPTER FOUR

RESULTS

4.1 Study of exfoliated and extracted teeth

The results of the preliminary visual examination, photographic examination and microscopic examination are summarised in Tables 4.1 - 4.9.

4.1.1 Preliminary visual examination

Preliminary visual inspection of the teeth was carried out using the scoring criteria shown in Table 3.1. This system assesses tooth wear, irrespective of its aetiology or type. All tooth surfaces were examined. Scoring of all teeth had been repeated after a two day interval to check reproducibility.

Reproducibility of scoring

Results of repeated assessments using visual examination are shown in Table 4.1. There was agreement in all but one case scored as having erosion into enamel on the second occasion only. The kappa value was 0.96.

Findings

Findings at the preliminary visual inspection are summarised in Table 4.2. The results show that on visual examination, 10 of the forty-one teeth appeared to have no detectable tooth tissue loss, 14 teeth had visible tooth tissue loss extending into enamel, and 17 teeth had loss that could be seen to extend into dentine. In no case was there a degree of wear that obviously involved the pulp, although in the case of one tooth (No. 7) there was a localised discoloration indicating its close proximity.

In describing the teeth, reference was made to the site of tooth wear seen visually. In 27 of the 31 teeth seen to be affected it involved the incisal edge or cuspal tip, and it involved the palatal surface in 19 teeth.

In relation to tooth type, tooth wear extending into dentine was recorded in 15 of the incisor teeth (13 central incisor and 2 lateral incisor teeth), and 2 of the canines. Tooth wear confined to enamel was reported in 10 of the incisors (4 central incisor teeth and 6 lateral incisor teeth) and 4 of the canines.

Using the defined scoring system, 10 teeth had a score of 0 indicating normal appearance without tooth wear, 14 teeth had a score of 1 indicating tooth wear into enamel and 17 teeth had a score of 2 indicating tooth wear into dentine.

This study was not confined to caries free teeth. In the case of 15 teeth, caries was visually obvious. Tooth wear was also visible in 10 of those with caries elsewhere on the crown. In 6 cases both caries and tooth wear had affected smooth tooth surfaces.

Table 4.1 **Reproducibility of Visual scores**

Exam 1	Exam 2				
	0 Normal	1 Enamel	2 Dentine	3 Pulp	Total
0 Normal	9	1			10
1 Enamel		14			14
2 Dentine			17		17
3 Pulp					
Total	9	15	17		41

Table 4.2 **The Visual Scoring**

Slide No	Tooth type	Clinical view	Scores	With caries
1	Central incisor	Tooth wear into dentine on the palatal and the incisal surfaces.	2	
2	Central incisor	Tooth wear into dentine on the palatal and the incisal surfaces.	2	
3	Central incisor	Tooth wear into dentine on the palatal and the incisal surfaces.	2	
4	Lateral incisor	Normal, no wear seen, initial proximal caries present.	0	+ caries
5	Lateral incisor	Tooth wear into enamel on the palatal and the incisal surfaces.	1	
6	Canine	Normal, no wear seen.	0	
7	Central incisor	Tooth wear into dentine on the palatal surface (pulp shadow was seen).	2	
8	Central incisor	Tooth wear into enamel, with proximal caries present.	1	+ caries
9	Central incisor	Normal, no wear seen, proximal caries present.	0	+ caries
10	Central incisor	Tooth wear into dentine on the incisal surface.	2	
11	Central incisor	Slight tooth wear into enamel on the incisal surface, with initial labial caries.	1	+ caries
12	Central incisor	Normal, no wear seen, labial and proximal caries present.	0	+ caries
13	Central incisor	Tooth wear into enamel on the incisal surface, palatal caries present.	1	+ caries
14	Central incisor	Tooth wear into dentine on the incisal surface.	2	

15	Central incisor	Severe tooth wear into dentine on the incisal surface.	2	
16	Central incisor	Slight wear into enamel on the palatal surface, severe wear into dentine on the incisal surface.	2	
17	Lateral incisor	Slight tooth wear into enamel on the incisal surface.	1	
18	Canine	Slight wear into enamel on the palatal surface and on the cusp tip.	1	
19	Central incisor	Tooth wear into enamel on the palatal surface, mesial caries present.	1	+ caries
20	Lateral incisor	Normal, no tooth wear, mesial caries present.	0	+ caries
21	Canine	Slight tooth wear of enamel on the palatal surface.	1	
22	Canine	Normal, no tooth wear.	0	
23	Lateral incisor	Slight tooth wear of enamel on the incisal surface.	1	
24	Central incisor	Tooth wear into dentine on the palatal surface, and into enamel on the incisal surface.	2	
25	Lateral incisor	Normal, no tooth wear.	0	
26	Lateral incisor	Normal, no tooth wear, mesial caries present.	0	+ caries
27	Central incisor	Tooth wear into enamel on the palatal surface and into dentine on the incisal surface, restored buccal cavity present with recurrent of caries.	2	+ caries
28	Lateral incisor	Tooth wear into enamel on the incisal surface.	1	
29	Lateral incisor	Very slight tooth wear into enamel on the palatal surface, mesial caries present.	1	+ caries
30	Canine	Very slight tooth wear into enamel on the palatal surface and on the cusp tip.	1	
31	Lateral incisor	Normal, no tooth wear.	0	
32	Canine	Tooth wear into enamel on the palatal surface, tooth wear into dentine on the cusp tip.	2	
33	Lateral incisor	Very slight tooth wear into enamel on the palatal and the incisal surfaces, 2 small brown spots on the labial surface (developmental abnormality).	1	
34	Lateral incisor	Normal, no tooth wear.	0	

35	Lateral incisor	Tooth wear into dentine on the incisal surface.	2	
36	Lateral incisor	Tooth wear into dentine on the disto-palatal surface.	2	
37	Central incisor	Tooth wear into dentine on the palatal and incisal surfaces, presence of caries on the palatal surface, caries on the labial surface.	2	+ caries
38	Canine	Tooth wear into enamel on the cusp tip.	2	
39	Central incisor	Tooth wear into dentine on the palatal and incisal surfaces, presence of caries on the palatal surface, caries on the labial surface.	2	+ caries
40	Central incisor	Tooth wear into dentine on the palatal and the incisal surfaces, mesial caries present.	2	+ caries
41	Canine	Slight tooth wear into enamel on the palatal and the incisal surface, mesial caries present.	1	+ caries

4.1.2 Photographic assessment

Photographs of the 41 teeth were assessed using the same criteria as had been employed at the visual inspection. They were scored twice, with a two day interval to determine reproducibility.

Reproducibility of scoring

Data showing reproducibility of scores made from photographs is given in Table 4.3, and details of findings of the photographic assessment are given in Table 4.4.

Findings

The level of agreement in scoring the presence/absence of wear was the same as that seen on visual inspection, with agreement in the case of all but one tooth. Agreement as to the extent of wear was less; 5 teeth were scored as having wear confined to enamel on the first occasion, but on the second occasion this was scored as extending into dentine. The estimated Kappa value was correspondingly lower at 0.77.

Results in Table 4.4 show that on photographic examination, 10 teeth were recorded as normal with no detectable tooth tissue loss, and 31 teeth were recorded as having tooth wear. Of the thirty-one cases, 14 teeth had tooth tissue loss extending into enamel, and 17 teeth had loss extending into dentine. In the tooth where localised discoloration had been seen on visual inspection (No. 7), this was also seen photographically.

The extent of tooth tissue loss was determined using the scores as before. Ten teeth were awarded a score of 0, 14 teeth a score of 1, and 17 teeth a score of 2. As in the case of visual inspection, no scores of 3 were recorded.

The caries seen on visual inspection was also obvious on photographs. The site of tooth wear reported was also the same. Accordingly, 12 teeth were recorded as having wear affecting incisal edges, 4 teeth were recorded as having loss confined to smooth surfaces, and 15 teeth were recorded as having both types of wear.

Table 4.3 **Reproducibility of Photographic scores**

Exam 1	Exam 2				
	0 Normal	1 Enamel	2 Dentine	3 Pulp	Total
0 Normal	9	1			10
1 Enamel		9	5		14
2 Dentine			17		17
3 Pulp					
Total	9	10	22		41

Table 4.4 **The Photographic Scoring**

Slide No	Tooth type	Photographic view	Score	With caries
1	Central incisor	tooth wear into dentine on the palatal and the incisal surfaces.	2	
2	Central incisor	tooth wear into dentine on the palatal and the incisal surfaces.	2	
3	Central incisor	tooth wear into dentine on the palatal and the incisal surfaces.	2	
4	Lateral incisor	No tooth wear, initial proximal caries.	0	+ caries
5	Lateral incisor	Tooth wear into enamel on the palatal and the incisal surfaces.	1	
6	Canine	No tooth wear.	0	
7	Central incisor	Tooth wear into dentine on the palatal surface (pulp shadow was seen).	2	
8	Central incisor	Tooth wear into enamel on the incisal surface, proximal caries present.	1	+ caries
9	Central incisor	No tooth wear, proximal caries present.	0	+ caries
10	Central incisor	Tooth wear into dentine on the incisal surface.	2	
11	Central incisor	Slight tooth wear into enamel on the incisal surface, initial labial caries.	1	+ caries
12	Central incisor	No tooth wear, labial and proximal caries present.	0	+ caries
13	Central incisor	Tooth wear into enamel on the incisal surface, palatal caries present.	1	+ caries
14	Central incisor	Tooth wear into dentine on the incisal surface.	2	

15	Central incisor	Severe tooth wear into dentine on the incisal surface.	2	
16	Central incisor	Slight wear on the palatal surface and severe wear into dentine on the incisal surface.	2	
17	Lateral incisor	Slight tooth wear into enamel on the incisal surface.	1	
18	Canine	Slight wear into enamel on the palatal surface and on the cusp tip.	1	
19	Central incisor	Tooth wear into enamel on the palatal surface, mesial caries present.	1	+ caries
20	Lateral incisor	No tooth wear, mesial caries present.	0	+ caries
21	Canine	Slight tooth wear into enamel on the palatal surface.	1	
22	Canine	No tooth wear.	0	
23	Lateral incisor	Slight tooth wear into enamel on the incisal surface.	1	
24	Central incisor	Tooth wear into dentine on the palatal surface, tooth wear into enamel on the incisal surface.	2	
25	Lateral incisor	No tooth wear.	0	
26	Lateral incisor	No tooth wear, mesial caries present.	0	+ caries
27	Central incisor	Tooth wear into enamel on the palatal surface and into dentine on the incisal surface, the presence of restored buccal cavity with recurrent of caries.	2	+ caries
28	Lateral incisor	Tooth wear into enamel on the incisal surface.	1	
29	Lateral incisor	Very slight tooth wear into enamel on the palatal surface, mesial caries present.	1	+ caries
30	Canine	Very slight tooth wear into enamel on the palatal surface and on the cusp tip.	1	
31	Lateral incisor	No tooth wear.	0	
32	Canine	Tooth wear into enamel on the palatal surface, tooth wear into dentine on the cusp tip.	2	
33	Lateral incisor	Very slight tooth wear into enamel on the palatal and the incisal surfaces, the presence of 2 small brown spots on the labial surface (developmental abnormality).	1	
34	Lateral incisor	No tooth wear.	0	

35	Lateral incisor	Tooth wear into dentine on the incisal surface.	2	
36	Lateral incisor	Tooth wear into dentine on the disto-palatal surface.	2	
37	Central incisor	Tooth wear into dentine on the palatal and incisal surface, presence of caries on the palatal surface, caries on the buccal surface.	2	+ caries
38	Canine	Tooth wear into enamel on the cusp tip.	2	
39	Central incisor	Tooth wear into dentine on the palatal and incisal surfaces, presence of caries on the palatal surface, caries on the labial surface.	2	+ caries
40	Central incisor	Tooth wear into dentine on the palatal and the incisal surfaces, mesial caries present.	2	+ caries
41	Canine	Slight tooth wear of enamel on the palatal and the incisal surfaces, mesial caries present.	1	+ caries

4.1.3 Examination of sectioned teeth

Sections of the forty-one teeth were examined under the microscope using the criteria employed earlier and summarised in Table 3.1. All sections were examined again after a two week interval, to estimate reproducibility of this form of assessment (Table 4.5).

Reproducibility of scoring

Scores awarded to the forty-one sections were the same on all but two occasions. In both cases, tooth wear was agreed to have occurred but there was disagreement as to its extent. It was scored as affecting dentine on the first occasion, but confined to enamel on the second in each case. The estimate Kappa value for the forty-one repeat examinations was 0.89.

Findings

Findings at the examination of sectioned teeth are summarised in Table 4.6. Sections of the forty-one teeth showed where destruction of the enamel had occurred. A tooth was recorded as normal when enamel was present and an intact smooth surface visible. Tooth wear was recorded when an irregular surface was seen and where a partial or complete loss of enamel had occurred. Where diffuse demineralisation was visible adjacent to an area of tooth wear, this was regarded as being a consequence of erosion. On microscopic examination, 8 of the teeth appeared to have no detectable tooth tissue loss, with tooth wear evident in 33 cases.

In only 4 cases was wear confined to enamel, with 29 cases showing loss of tooth tissue involving dentine. In no case was pulp exposure obvious. Diffuse demineralisation was seen in 11 cases with loss of tooth tissue, but not in the remaining 22.

Using the scoring system employed for visual and photographic assessments, 8 teeth had a score of 0, 4 a score of 1 and 29 a score of 2.

Secondary dentine formation was reported in 17 cases. The caries reported in earlier examinations was confirmed under the microscope when localised area of demineralisation were seen.

Table 4.5 **Reproducibility of Microscopic scores**

Exam 1	Exam 2				
	0 Normal	1 Enamel	2 Dentine	3 Pulp	Total
0 Normal	8				8
1 Enamel		4			4
2 Dentine		2	27		29
3 Pulp					
Total	8	6	27		41

Table 4.6 **The Microscopy Scoring**

Slide No	Tooth type	Microscopic view	Score	With caries
1	Central incisor	Tooth wear on the incisal and the palatal surfaces into dentine. Secondary dentine formation was seen. Demineralisation on the labial and the palatal surfaces.	2	
2	Central incisor	Tooth wear on the incisal and the palatal surfaces into dentine. Secondary dentine formation was seen. Demineralisation on the labial and the palatal surfaces.	2	
3	Central incisor	Tooth wear on the incisal and the palatal surfaces into dentine. Secondary dentine formation was seen. Demineralisation on the labial and the palatal surfaces.	2	
4	Lateral incisor	Tooth wear on the incisal into dentine. Secondary dentine formation was seen. Section did not include caries.	2	
5	Lateral incisor	Tooth wear on the incisal surface extending into enamel.	1	
6	Canine	Normal, no evidence of tooth wear.	0	
7	Central incisor	Tooth wear on the palatal surface into dentine. Secondary dentine formation was seen.	2	
8	Central incisor	Slight tooth wear at the incisal surface into enamel. Localised demineralisation on the palatal and the labial surfaces due to caries.	1	+ caries

9	Central incisor	Normal, localised demineralisation on the palatal and labial surfaces due to the presence of caries.	0	+ caries
10	Central incisor	Tooth wear at the incisal surface and on the palatal surface into dentine. Secondary dentine formation. Demineralisation on the palatal surface adjacent to eroded area (appearance typical of erosion).	2	
11	Central incisor	Tooth wear at the incisal surface into dentine. Secondary dentine formation was seen. Enamel is thinner on the palatal with diffuse demineralisation on the palatal surface. Localised demineralisation on the labial surface due to caries.	2	+ caries
12	Central incisor	Tooth wear at the incisal surface into enamel. 3 areas of local demineralisation on the palatal surface and one on the labial surface due to caries.	1	+ caries
13	Central incisor	Tooth wear at the incisal surface into dentine. Localised area of demineralisation on the buccal and on the palatal surfaces due to caries.	1	+ caries
14	Central incisor	Tooth wear at the incisal edge and on the palatal surface into dentine. Secondary dentine formation was seen.	2	
15	Central incisor	Severe tooth wear at the incisal edge into dentine. Secondary dentine formation was seen. Diffuse demineralisation on labial and palatal surfaces with irregular surfaces seen.	2	
16	Central incisor	Severe tooth wear at the incisal and palatal surfaces extending into dentine. Secondary dentine formation. Enamel thinner on the palatal surface with slight demineralisation present.	2	
17	Lateral incisor	Tooth wear at the incisal surface extending into dentine. Enamel is thinner on the palatal surfaces.	2	
18	Canine	Tooth wear at the incisal surface extending into dentine.	2	
19	Central incisor	Tooth wear at the incisal into dentine. Localised demineralisation on the labial and palatal surfaces due to caries.	2	+ caries
20	Lateral incisor	Normal, no tooth wear. (Section did not include the caries part).	0	
21	Canine	Tooth wear on the incisal surface extending into dentine.	2	
22	Canine	Normal, no tooth wear.	0	

23	Lateral incisor	Tooth wear at the incisal surface extending into dentine.	2	
24	Central incisor	Tooth wear at the incisal and palatal surfaces into dentine. Secondary dentine formation. No demineralisation seen.	2	
25	Lateral incisor	Normal, no evidence of tooth wear.	0	
26	Lateral incisor	Normal. (the section did not include caries present on visual examination).	0	
27	Central incisor	Tooth wear at the incisal and the palatal surfaces into dentine. Restored labial caries. Secondary dentine formation was seen.	2	+ caries
28	Lateral incisor	Tooth wear at the incisal surface extending into dentine, slight demineralisation of labial surface.	2	
29	Lateral incisor	Tooth wear at the incisal surface into dentine, (the section did not include caries).	2	
30	Canine	Tooth wear at the incisal surface into dentine, slight demineralisation on the labial surface.	2	
31	Lateral incisor	Normal, no tooth wear. Crack is present on the incisal surface. Secondary dentine formation.	0	
32	Canine	Tooth wear at the incisal surface into dentine. Part of the surface loss on the palatal surface with demineralisation seen in enamel.	2	
33	Lateral incisor	Tooth wear at the incisal surface into dentine. Demineralisation of the labial surface.	2	
34	Lateral incisor	Normal, no tooth wear.	0	
35	Lateral incisor	Tooth wear at the incisal surface extending into dentine. Secondary dentine formation.	2	
36	Lateral incisor	Tooth wear on the palatal surface into dentine. Demineralisation on the labial surface and slight demineralisation on the palatal surface next to area of reduced enamel thickness.	2	
37	Central incisor	Tooth wear of the incisal and palatal surfaces into dentine. Secondary dentine formation. Labial caries with localised demineralisation. Diffuse demineralisation on the palatal surface next to area of reduced enamel thickness.	2	+ caries
38	Canine	Tooth wear into dentine at the cusp tip.	2	

39	Central incisor	Tooth wear on the incisal and the palatal surface into dentine. Secondary dentine formation. Localised demineralisation on the labial surface due to caries.	2	+ caries
40	Central incisor	Tooth wear on the incisal and the palatal surfaces into dentine. Secondary dentine formation. Demineralisation of the palatal surface next to area of reduced enamel thickness.	2	
41	Canine	Tooth wear at the incisal surface into dentine, No obvious demineralisation seen.	2	

The relationship between scores on visual inspection and photographic evaluation is summarised in Table 4.7, that between visual inspection and those made on examination of slides in Table 4.8 and that between photographic evaluation and microscopy in Table 4.9.

Visual vs Photographic Scores

Correspondence between scores at visual inspection and on photographic assessment of the forty-one teeth were exact. These are shown in Table 4.7.

Visual vs Microscopic Scores

On histological examination it was apparent that of the 10 teeth without tooth surface loss visually, 1 had evidence of loss extending into enamel, and 1 into dentine. Of the 14 with visual evidence of tooth loss into enamel, dentine was exposed in all but 3 cases. Tooth loss into dentine, was confirmed on microscopy in all 17 cases where it had been seen visually (Table 4.8).

Using microscopy as the 'gold standard' and wear in enamel as the cut off point, the sensitivity of visual inspection was 0.94, and the specificity was 1.0. Using wear into dentine as the cut off point, sensitivity was reduced to 0.58.

Photographic vs Microscopic scores

The results of assessment of photographic examination vs microscopic examination are shown in Table 4.9. Findings from this Table were similar to those from Table 4.8, and sensitivity and specificity values were the same.

Table 4.7 **Visual scores Vs Photographic scores**

Visual	Photographic score				
	0 Normal	1 Enamel	2 Dentine	3 Pulp	Total
0 Normal	10				10
1 Enamel		14			14
2 Dentine			17		17
3 Pulp					
Total	10	14	17		41

Table 4.8 **Visual scores Vs Microscopic scores**

Visual	Microscopic score				
	0 Normal	1 Enamel	2 Dentine	3 Pulp	Total
0 Normal	8	1	1		10
1 Enamel		3	11		14
2 Dentine			17		17
3 Pulp					
Total	8	4	29		41

Table 4.9 **Photographic scores Vs Microscopic scores**

Photo	Microscopic score				
	0 Normal	1 Enamel	2 Dentine	3 Pulp	Total
0 Normal	8	1	1		10
1 Enamel		3	11		14
2 Dentine			17		17
3 Pulp					
Total	8	4	29		41

4.2 The Survey of kindergarten children in Jeddah

4.2.1 The Response

The response to the survey is summarised in Table 4.10. All 4-5 years old children attending the schools selected were eligible to take part. Forms were therefore sent to parents of a total of 1554 children. These were returned for 1063. Totals for private and public schools are given in Table 4.10 and show that a higher proportion of forms were completed and returned for children at private schools (85% returned) than for those at public schools (50% returned). Of those children for whom forms were returned, 33 were absent at all visits to the school and 43 were unable to co-operate sufficiently to take part. Results for the clinical examination therefore relate to the 987 children who were dentally examined in schools.

Of the children examined, 858 had photographs taken. Of the remainder, the parents of 52 did not consent to this part of the examination and 77 were not able to co-operate sufficiently. Forty eight children had allowed only one photograph to be taken but 2 were taken for each of the remaining 810 children.

On developing, four films proved partly or wholly unsatisfactory with the result that one or both photographs proved to be insufficient quality for 131 children. Results for photographic examination therefore relate to 727 children, each of whom had both labial and palatal views, 514 of those at private schools and 213 from public schools.

Table 4.10 **The Response to the Survey in 11 Private and 6 publicly Funded Kindergartens in Jeddah**

	Number (&%) of Children		
	Private Kindergartens	**Publicly Funded Kindergartens**	**Total**
No. Attending Schools	810	744	1554
No. Returning Forms	691 (85%)	372 (50%)	1063(68%)
No. Examined	642 (79%)	345 (46%)	987 (64%)
No. Having Photographs	586 (72%)	272 (37%)	858 (55%)
No. With Two Satisfactory Photographs	514 (63%)	213 (29%)	727 (47%)

Results of the Clinical Examination

Results drawn from clinical examination and completed questionnaires for 987 children attending private and public kindergarten schools in Jeddah are summarised in Tables 4.11 to 4.59 (pages 165 to 196) and Figures 5,6 and 7 (pages 197 to 199).

4.2.2 The Sample

The sample of 987 children included 511 boys and 476 girls. Six hundred and forty two were from private schools and 345 from kindergartens that were publicly funded. There was no evidence of any systematic gender difference between the two types of kindergarten.

The age groups of the children taking part in the clinical examination are summarised in Table 4.11. The youngest child was 2 years and 11 months and the oldest 5 years and 9 months at the time of examination. There was a significant difference between schools in age groups of the children, with a higher proportion of those attending private school being aged 5, and more of those attending public school aged 4 years of age or less at their last birthday.

Children from both private and public schools had been included to ensure that the sample represented a spectrum of social classes. Social class of families was also measured independently through information regarding occupation of each child's father and education level of the mothers. This information is summarised in Table 4.12 and 4.13.

Of the total sample, 211 children had fathers from the higher professions and 125 from other professions. Four hundred and sixty one were classified as from the middle classes and 190 as having fathers with unskilled or other occupations (Table 4.12).

There were marked differences between schools in relation to occupation of the fathers. Thus, for example, fathers of 260 (40%) children attending private schools came from the professions or higher professions, whereas only 76 (22%) of those of children attending public schools did so.

Almost two thirds (629 children, 64%) of the children's mothers had an education which included a period of college and sometimes postgraduate education, 258(26%) had been educated to secondary or high school. Eleven mothers (1%) had received no education or had either been educated only to primary school level and 89 (9%) did not indicate the level of education (Table 4.13). There was some difference between the two types of school in relation to mother's education; slightly more of the mothers whose children

attended public school than those whose children attended private kindergartens had been educated to college level and beyond (68% compared to 62%).

4.2.3 Findings at Clinical Examination

I. *Erosion*

Of the 987 children included in the survey, 309 (31%) had evidence of tooth tissue loss affecting labial and/or palatal surfaces of one or more of their maxillary incisor teeth at clinical examination. These children were regarded as having loss that was wholly or partly a consequence of erosion. In the case of a further 389 (39%) wear was evident but was confined to incisal edges of the teeth. In the case of these children tooth tissue loss was regarded as being primarily or wholly a result of attrition and they were excluded from analysis relating to erosion. Wear involving incisal edges was also seen in 292 of the 309 with erosion.

For 186 of those with erosion this was scored as being confined to enamel but for 123 it had extended into dentine and/or pulp of the tooth. Of the 309 children with erosion 180 had central incisors affected, 6 had the lateral incisors only affected and 123 had erosion affecting both types of incisor teeth.

In relation to surface type, 301 children had erosion affecting palatal surfaces, 1 child had erosion confined to buccal surfaces and 7 had erosion on both palatal and buccal surfaces. For those children with erosion, the mean number of teeth affected was 2.7 ($\pm$ 0.97) per child. The mean number of surfaces affected was the same, at 2.7 ($\pm$ 1.02) per child.

The prevalence and severity of erosion in relation to gender is shown in Table 4.14. Slightly more boys than girls had evidence of erosion but the difference was small in real terms and related only to erosion confined to enamel. Neither prevalence nor severity were significantly related to gender.

Prevalence of erosion in relation to age is shown in Table 4.15. Prevalence showed some evidence of an increase with age, 164 (29%) of those aged 4 or less showed evidence of erosion compared to 145 (35%) of those aged 5. The trend was apparent in both erosion confined to enamel and in the case of the more severe type where dentine and/or pulp were affected. Neither the relationship between prevalence and age, nor that of it's severity and age were statistically significant.

Prevalence of erosion in relation to school type is summarised in Table 4.16. Because samples from private and publicly funded kindergartens differed in age structure, age adjusted estimates are also included. Results suggested that there was little difference in prevalence between the two school types even when estimates were adjusted for differences in age distribution. Two hundred and three (32%) of the children in private schools were affected and 106 (31%) of those attending public schools. Equivalent age adjusted estimates were 32% and 33% for the two types of kindergarten respectively. Neither proved significantly different.

II. *Caries*

Findings at clinical examination in relation to caries are summarised in Table 4.17 to 4.19. Caries was seen in 720 (73%) of the 987 children examined (Table 4.17). Four hundred and fifty four (71%) children from private schools and 266 (77%) of those from public schools had some caries experience. Comparison of the proportions with caries at each school showed the difference of 6% between them to be just significant.

Rampant caries (i.e caries affecting smooth surfaces of 2 or more maxillary incisors) was diagnosed in 336 (34%) of all the children examined. This total included 199 (31%) children from private schools and 137 (40%) from public schools. As in the case of caries, comparison of the two sample proportions with rampant caries showed the difference of 9% between schools to be statistically significant.

Mean dmft for the 987 children was 4.80 (± 4.87) per child and mean dmfs 12.67 (± 15.46) per child (Table 4.18). Caries experience was made up largely of decayed teeth. These made up an average dt component of 3.97 (± 4.37) per child, 83% of the total dmft and 9.87 (±13.03) surfaces, 78% of the average dmfs value.

In terms of treatment, more teeth had been filled than extracted, mean ft was 0.51(± 1.54) per child compared to an average mt of 0.32 (± 0.97).

There was a difference between school types in dmft and dmfs (1.11 in dmft and 2.96 in dmfs) with lower values for children in private schools. Distribution of dmft and dmfs values were skew and differences were tested using Mann Whitney 'U' tests. They were confirmed as statistically significant (P = 0.002 for dmft and P = 0.009 for dmfs)

Prevalence and severity of caries according to the age group at the time of examination for the two types of schools are shown in Table 4.19. Prevalence increased with age, from 61% at age 3 up to 76% in 5 year old children. dmft increased from a mean of 3.6 teeth per child at 3 up to 5.1 at 5 years of age. Similarly dmfs increased from 8.64 to 13.90.

III. *Erosion and Caries*

The relationship between presence of caries and of erosion is shown in Table 4.20, between presence of rampant caries and of erosion in Table 4.21 and between presence of caries excluding rampant caries and of erosion in Table 4.22.

Of the 720 children with any caries experience 237 (33%) had evidence of erosion. This was 6% higher than the 27% of children without caries who had erosion, a difference that was not statistically significant even when analysis included the severity of erosion.

Fewer children with rampant caries (96 of the 336; 29%) had evidence of erosion compared to those without this form of disease (213 of 651; 33%). This difference was statistically not significant including when severity of erosion was considered.

In contrast, the relationship between presence of caries excluding rampant caries and of erosion was statistically significant. Of the 384 children who had caries but not rampant caries, 141 (37%) had erosion, a significantly higher proportion than the 72 (27%) out of 267 who were clinically caries free.

4.2.4 Findings from photographic Examination

Results drawn from assessment of the photographs for erosion are summarised in Tables 4.23 and 4.24. Those derived from clinical examinations of the same children are repeated in the tables for ease of comparison.

Of the 727 children included in the analysis of photographs, 220 (30%) had photographic evidence of tooth tissue loss affecting labial and/or palatal surfaces of one or more of their maxillary incisor teeth (Table 4.23).

Scoring from photographs, 156 (71%) children were scored as having erosion confined to a score of 1 and 60 (27%) were scored as having evidence of erosion extending into dentine (score 2). Four children (2%) were seen to have erosion with a score of 3 (involving pulp) from the photographs.

Prevalence estimates derived from clinical examination for the same children were higher than those for photographs (36% compared to 30%). The difference was seen especially in prevalence of more extensive erosion extending into dentine (14% clinically compared to 8% on photographs). There was little difference in the prevalence of erosion confined to enamel and no difference in the very small numbers with erosion affecting pulp. The difference when severity scores were taken into account was highly significant.

Of the 220 children diagnosed from photographs as having erosion 151 had central incisors affected, 3 had lateral incisors affected and in 66 cases erosion had affected both types of primary incisor. Estimates for central and lateral incisors alone were broadly similar to those from clinical examination where 155 had central incisors

affected, 4 had lateral incisors affected but more (105), were diagnosed clinically as having erosion affecting both tooth types.

In relation to surface type, 217 children had palatal erosion, 3 had erosion on both palatal and buccal surfaces and none had buccal erosion diagnosed from photographs. Clinically 258 of the same 727 children had been diagnosed as having palatal erosion, 6 were diagnosed as having both surface types affected and none had only buccal erosion affected (Table 4.24).

A total of 545 surfaces were diagnosed from photographs as showing erosion. 405 (74%) were scored as 1, 135 (25%) scored as 2 and 5 (1%) scored 3.

In the same children, 697 surfaces were scored clinically as having erosion, 449 (64%) as score1, 241(35%) as score 2 and 7 (1%) as score 3.

Using photographs the mean number of teeth affected per child for all 727 cases was 0.73 (±1.21) per child and the mean number of surfaces 0.73 (± 1.22) per child.

For children who had erosion the mean number of teeth affected per child was 2.41 (± 0.88) per child and the mean number of surfaces 2.42 (± 0.90) per child.

This compares to values at clinical examination of teeth affected per child for the 727 cases of 0.98 (± 1.43) teeth and 0.99 (± 1.45) surfaces per child. For children who had erosion the mean number of teeth affected was 2.71 (± 0.97) and the mean number of surfaces 2.73 (± 1.03) per child.

4.2.5 Comparison of teeth and surfaces with information from clinical and photographic data

Estimates of prevalence alone may mask disagreement. The level of agreement between clinical versus photographic scoring in terms of subjects with and without erosion and its severity is shown in Table 4.25 and in relation to surfaces in Table 4.26.

In terms of children affected, agreement was seen in a total of 598 cases (82%). Agreement was seen in 439 of cases as to no erosion being present (83% of the total scored as having no erosion), in 104 cases when it was confined to enamel (49% of the total who had values confined to score 1), in 51 cases when it was confined to dentine (46% of the total) and in 4 cases when it extended into the pulp (100%).
In 68 cases scored clinically as having erosion it was not detected photographically and in 24 cases the reverse was true. In 31 cases there was agreement that erosion was present but it was scored as confined to enamel photographically but extending into dentine clinically. In 6 cases a child was scored as having more severe erosion using photographs than clinically. The estimated kappa statistic for subjects was 0.64 when grading was included and when considering if any erosion was present, it was 0.72.

The level of agreement between clinical versus photographic scoring in terms of surfaces affected with and without erosion and its severity is shown in Table 4.26.
When the all the surfaces were compared, agreement was seen in 4958 (93%) of the total of 5322 surfaces. The estimated kappa value was 0.68.

Agreement was seen in 4576 of surfaces as to no erosion being present (95%), in 265 when it was confined to enamel (45%), in 112 when it was confined to dentine (42%) and in 5 when it had extended to involve the pulp (100%).

4.3 Results of the questionnaire

For the sake of clarity results for the children at the private and publicly funded kindergartens have been combined for purposes of relating erosion to potential aetiological factors. Because they differed not only in social class but also in age of children attending, kindergarten type was retained as a variable in multivariate analyses. Results are considered a) in relation to erosion and

b) in relation to caries at clinical examination.

4.3.1 Results of questionnaire in relation to erosion

Measures used for social class were occupation of the child's father and the educational level of the child's mother. Prevalence of erosion in relation to these two measures is shown in Tables 4.27 and 4.28.

Social class based on occupation of the child's father:

Sixty (28%) of the children whose fathers were from the higher professions had erosion, as did 45 (36%) of those from professions, 149 (32%) of those from the middle class and 54 (28%) of those whose fathers held unskilled or other occupations (Tables 4.27). Differences were not statistically significant.

Social class based on education level of the child's mother:

The relationship between erosion and the mother's educational level is summarised in Table 4.28. Erosion was seen in 192 (31%) of those whose mothers had been educated to college level or beyond and 84 (33%) of those educated to secondary and high school level. Erosion appeared lowest (27%) among children of mothers with primary or no education but numbers in this group were very small. Differences in relation to educational level were not significant. Not all mothers indicated their level of education, therefore this did not add up to the total in the study.

There was no consistent trend for the prevalence of erosion to relate to social class, with values ranging from 28% to 36% (for social class based on fathers occupation) and 27% to 33% (for social class based on mothers education) between different social classes.

Infant feeding:

Of the 987 children included in the study, five hundred and fifty four were both breast and bottle fed, 260 had been wholly breast fed and 173 wholly bottle fed (Table 4.29).

The relation between feeding type and social class based on father's occupation (Table 4.30) was highly significant, with more of those children from lower social classes having been wholly or partly breast fed (173 of 260 children (67%) compared to 87 in higher social classes (34%).

The relation between feeding type and social class based on mother's educational level (Table 4.31) proved just statistically significant with more of those with mothers with lower education level having been wholly or partly breast fed (90 of 269 children (34%) compared to 150 of 629 children (24%) with mothers who had reached a higher educational level.

Erosion in relation to infant feeding practices is shown in Table 4.29. Little difference was seen in prevalence of erosion or it's severity between the types of feeding practised. Erosion was seen in 171 of the children (31%) who were both breast and bottle fed, 84 (32%) of the children who were breast fed only and 54 (31%) of the children who had been solely bottle-fed. The difference was not statistically significant even when the severity of erosion was taken into account.

Drinking from a feeding bottle when the child was a baby:

In their replies to the questionnaires 818 of the parents said that their children had drinks other than milk from the infant feeding bottle when their child was a baby. Six hundred and eight children had pure fruit juice and 56 children had fruit syrup, 95 had packed fruit juice and 580 had herbal drinks. In considering the relationship between having these drinks from the feeding bottle when the child was a baby and erosion (Table 4.32), a similar prevalence of erosion was seen when pure fruit juice was consumed (32%) as when it was not (31%). There were large differences in prevalence amongst those who did and who did not consume fruit syrup, packed fruit juice or herbal drinks, 45% (fruit syrup), 39% (packed fruit juice), 29% (herbal drinks) compared to 31%, 31% and 35% respectively. Differences in prevalence between having and not having each type of drink were not statistically significant with the exception of that for fruit syrup and for herbal drinks. When differences in the severity of erosion were considered that for packed fruit juice was also significant.

Bedtime drinks from a feeding bottle when the child was a baby:

Two hundred and eighty two children had reportedly been given pure fruit juice from a feeding bottle at bedtime, naptime or during the night, 35 had fruit syrup, 74 had packed fruit juice, 356 had herbal drinks and 278 had never had any of these drinks at bedtime. The relationship between each bedtime drink and erosion is shown in Table 4.33. Erosion was found in ninety six of the children (34%) of those who consumed pure fruit juice from a feeding bottle, 18 (51%) of those having fruit syrup, 30(41%) of those having packed fruit juice, 101 (28%) of those having herbal drinks and in 88 (32%) of those who had never had any of these drinks at bed time. In each case erosion was most often of the mild form affecting only enamel. Differences between having and not having each type of drink at bed time were not statistically significant with the exception of that for fruit syrup.

Bedtime drinking habits at the time of the survey:

The relationship between bedtime drinks at the time of the examination and erosion is shown in Table 4.34.

At the time of the study 144 of the children had pure fruit juice, 65 had fruit syrup, 108 had packed fruit juice, 15 had herbal drinks and 90 had fizzy drinks at bedtime. Six hundred and forty eight of the children were not given any particular drink at bedtime of whom 203 (31%) had evidence of erosion.

A higher prevalence of erosion was seen when fruit syrup was given at bed time than when pure fruit juice, packed fruit juice, herbal drinks or fizzy drinks were given at this time (45% compared to 35%, 36%, 40% and 33% respectively for the types of drink). Differences between having and not having each type of drink at bedtime were not statistically significant with the exception of that for fruit syrup.

Frequency of potentially erosive drinks:

The relationship between frequency of having drinks such as pure fruit juice, fizzy drinks and diluted fruit syrups, which have been considered as erosive, at the time of the study and prevalence of erosion is shown in Table 4.35. Not all mothers indicated the frequency of their children having the selected drinks and number therefore do not always add up to the total in the study.

There was little obvious difference in prevalence of erosion between those having pure fruit juices once or twice per day and those having them less often. One hundred and thirty five children were given pure fruit juices once or twice per week or less, of whom 43 (32%) had evidence of erosion. Amongst the 785 of children who had these once or more per day 241(31%) had erosion. Differences were seen in relation to fizzy drinks; 496 children had fizzy drinks once or twice per week or less, of whom 138 (28%) had evidence of erosion. Three hundred and ninety seven children had fizzy drinks at least once per day or more often, of whom 145 (37%) had evidence of erosion. This difference was highly significant.

Seven hundred and thirty children drank diluted fruit syrup once or twice per week or less, of whom 218 (30%) had evidence of erosion. Of the 154 of the children who had dilute fruit syrup drink once or more per day 59 (38%) had erosion. This difference was just significant.

Method of drinking:

Mothers were asked about the usual method of drinking used by their child. Answers are summarised in Table 4.36. Seventy three children were reported to use a feeder cup, 79 a cup with a straw, 519 a cup without a straw and 301 used a cup sometimes with, and sometimes without a straw. There appeared to be no very marked difference in the

prevalence of erosion and the way the drink was taken. Prevalence ranged from 30% amongst those normally using a cup to 34% amongst those using a straw. The difference in prevalence was not significant even when the severity of erosion was considered. Not all mothers indicated the method of drinking used by their children, therefore this again did not add up to the total in the study.

Fruits and food items:

The relationship between frequency of having selected fruits or food items suggested to be erosive and the prevalence of erosion is summarised in Table 4.37 and 4.38. As in the case of drinks, a proportion of families failed to indicate the frequency of consumption and totals are according less than the number of the children taking part in the study.

Of the fruits selected, the most frequently eaten fruit was apples; more than half the children (687; 70%) had apples to eat once a day or more often. Oranges were the next most popular fruit, eaten at least daily by 664 children. Grapefruits were the least popular, being eaten once a day or more by only 22 children.

Erosion affected 10 of the 22 who ate grapefruits daily or more often but in 8 cases it was confined to enamel. It also affected 32% of those consuming oranges once a day or more, 31% of those eating apples daily, 31% of those eating dates daily and 30% of those who ate other fruits (such as water melon, melon, bananas, guava or pears) every day or more. None of the differences between those who consumed each fruit at least daily and those having them less often were statistically significant.

Information about consumption of series of selected food items including tomato ketchup, olives and pickles, fruit yoghurt, and mayonnaise was also related to prevalence of erosion.

More than half of the children (591) had tomato ketchup at least daily, fewer (433) had fruit yoghurt, less than a third (202) had olives and pickles and only 177 children had mayonnaise every day. The highest prevalence of erosion was seen amongst children who had mayonnaise every day, 64 (36%) of this group showed erosion.

None of the differences between those who consumed each food item at least daily and those having them less often were statistically significant. The same was true when the severity of erosion was considered.

Iron and Vitamin C supplements:

Sixty four of the children were reported to have regular dietary iron supplements and 54 were reported to have regular Vitamin C. The relationship between having iron or Vitamin C supplements and the prevalence of erosion is shown in Table 4.39.

It was found that just over half (28 of the 54) of the children having Vitamin C had erosion and half of these (14) had erosion of the severe form extending into dentine and/or the pulp. The relationship between use of Vitamin C supplements and the prevalence of erosion was statistically highly significant.

Eighteen of those having iron supplements had evidence of erosion. The difference in prevalence in relation to iron supplements was statistically not significant.

Use of dummies dipped in honey or syrup:

Two hundred and fifteen of the 987 (22%) children who took part in the study had been given a dummy dipped in honey or sugary syrup (Table 4.40). Of these 64 (30%) had

erosion, compared to 244 (32%) of the 772 who had not done so. The relation between using dummies dipped in sugary syrup and erosion was not significant.

Tooth brushing:

Oral hygiene habits of the children that were investigated included frequency of brushing, age at which the child started brushing and whether brushing was carried out with help or without (Table 4.41). Not all mothers responded to these questions, so again totals did not add up to the total in the study.

Seven hundred and sixty eight children had their teeth brushed every day and for 181 this was done occasionally. Amongst those who brushed daily, 238 (31%) had erosion. This compared to 59 (33%) of those whose teeth were brushed occasionally. This difference was not significant.

Two hundred and fifty seven of the children had started to brush their teeth before the age of 12 months and 693 after the age of 12 months. Little difference was seen in prevalence of erosion when the habit started late compared to when it started earlier (32% compared to 31%). Again the difference was not significant.

Five hundred and forty children were reported to brush with help on most occasions but 409 children brushed alone without help. Again, little difference was seen in prevalence of erosion when the child brushed with assistance or without (31% compared to 32%). The relation between brushing with help or alone and erosion was statistically not significant.

None of the oral hygiene practices showed a statistically significant relation to erosion.

Multi-variate analysis

Multi-variate analysis was carried out using a stepwise multiple logistic regression to determine the factors which were independently related to the aetiology of erosion when others were held constant. Table 4.42 summarise findings when all children were included.

All variables were first considered and those failing to show a significant relationship to erosion then removed in stepwise fashion. The final model summarised in the Table showed the factors that remained as statistically significant were use of Vitamin C supplements (OR=2.6), the consumption of fruit syrup at bed/nap time when the child was a baby (OR=2.3) and frequent use of fizzy drinks at the time of the study (1-2 or more /day compared to 1-2 /week) (OR=1.5). Confidence intervals showed that in the case of Vitamin C and bedtime fruit syrup the OR in the population might have been as high as 4.7 and that for frequency of fizzy drinks as high as 1.9.

In this analysis caries did not emerge as a significant variable but Table 4.43 summarises findings when children with rampant caries were excluded. In these circumstances, caries proved to be a significant risk factor. The odds of having some erosion in children with caries excluding rampant caries was 1.5 and confidence intervals suggested the risk may have been as great as 2.1. Risk factors seen in the analysis for all children again emerged as significant when those with rampant caries were excluded.

4.3.2 Results of questionnaire in relation to caries

Results of the questionnaire related to erosion were also related to caries and rampant caries.

Social class based on occupation of the child's father:

Prevalence of caries and of rampant caries in relation to social class is shown in Table 4.44. The lowest prevalence of caries was seen in children from higher professional families. Prevalence in children from other social classes was little different. A similar pattern was seen in relation to rampant caries, with fewer children from higher professional families showing evidence of rampant caries. Differences in relation to social class were statistically significant for caries but not for rampant caries.

Social class based on education level of the child's mother:

The relationship between caries, rampant caries and the mother's education is summarised in Table 4.45. Trends were stronger than those seen in relation to social class, based on the father's occupation. The lowest levels of disease were seen amongst children of mothers educated to a college level or beyond. This was highly significant for both caries and for rampant caries.

Infant feeding:

The numbers (and percentages) of children with caries and with rampant caries in relation to type of infant feeding are shown in Table 4.46.

The prevalence of both caries and rampant caries were lowest amongst children who had been wholly bottle fed (65% were affected by caries and 27% by rampant caries)

and highest in those who had been breast fed (77% had caries and 40% had rampant caries).

The difference in relation to feeding type was significant for both caries and rampant caries. For those wholly or partly breast fed prevalence of caries increased consistently with increase in duration of breast feeding (Table 4.47). Sixty eight percent of the 194 breast fed for 4 months or less had caries, compared to 80% of those breast fed for more than one year. The same was true for rampant caries; children breast fed for less than 1 year had rampant caries less often than did those breast fed beyond that age.

Drinking from a feeding bottle when the child was a baby:

In considering the relationship between having specific types of drinks from a feeding bottle when the child was a baby and caries and rampant caries (Table 4.48), a similar prevalence of caries was seen when pure fruit juice, packed fruit juice or herbal drink was consumed (73% to 77%). There was higher prevalence of caries amongst those were reported to have consumed fruit syrup (82%). The same was true for rampant caries, although the number of children was small, but in neither case were differences statistically significant.

Bedtime drinks from a feeding bottle when the child was a baby:

The relationships between drinks given more specifically at bedtime when the child was a baby and caries and rampant caries are shown in Table 4.49. Caries was found in two hundred and twelve (75%) of those who consumed pure fruit juice from a bottle at bedtime, 28 (80%) of those having fruit syrup, 60 (81%) of those having packed fruit juice, 258 (73%) of those having herbal drinks and in 202 (73%) who had never had any of these drinks at bed time had caries.

The prevalence of rampant caries was higher in children having packed fruit juice (45%) than when pure fruit juice, fruit syrup or herbal drinks was consumed (38%, 31% and 34% respectively). The difference in rampant caries in relation to packed fruit juice was just statistically significant.

Bedtime drinking habits at the time of the survey:

The relationship between bedtime drinks at the time of the study, caries and rampant caries is shown in Table 4.50.

A similar prevalence of caries was seen when pure fruit juice, fruit syrup, packed fruit juice or fizzy drinks were given at bedtime at the time of the study (between 81% and 84%). A lower prevalence of caries was seen when herbal drinks were given (60%) but only 15 children were given herbal drinks at bedtime.

Although prevalence had been similar for all types of drink, differences between those who did and those who did not have each type were statistically significant for all, with the exception of herbal drinks.

The highest prevalence of rampant caries was seen in children who consumed fizzy drinks at bedtime at the time at the study (46%), followed by those who had packed fruit juice (44%). This was in turn higher than children who consumed drinks such as pure fruit juice and diluted fruit syrup (38% and 40% respectively). Differences were statistically significant for both fizzy drinks and packed juices. Although the number of the children involved was small, again the lowest prevalence of the disease was seen in children who consumed herbal drinks at bedtime (20%).

Frequency of current drinks:

The relationship between current frequency of having drinks such as pure fruit juice, fizzy drinks and diluted fruit syrups and prevalence of caries and rampant caries is shown in Table 4.51.

There was little obvious difference in prevalence of caries between those having pure fruit juices once or twice per day and those having these drinks less often. One hundred and thirty five children were given pure fruit juices once or twice per week or less, of whom 100 (74%) had evidence of caries, amongst the 785 of children who had these once or more per day 564 (72%) had caries. The difference was not significant.

Differences were more apparent in relation to fizzy drinks; 496 children had fizzy drinks once or twice per week or less, of whom 342 (69%) had evidence of caries. Three hundred and ninety seven children had fizzy drinks at least once per day or more often, of whom 300 (76%) had evidence of caries. The difference was significant.

Seven hundred and thirty children drank diluted fruit syrup once or twice per week or less. Of these 508 (70%) had evidence of caries; whereas of the 154 of the children who had these once or more per day 126 (82%) had caries. This difference was highly significant.

Similar trends were seen in rampant caries as in caries in relation to fizzy drinks. Thus 28% of those who had these once or twice per week or less showed rampant caries compared with 40% of those having fizzy drinks at least daily. The difference was also highly significant.

In relation to diluted fruit syrup 31% of those who had this type of drink once or twice per week or less had rampant caries compared with 39% of those having diluted fruit syrups once a day or more. The difference was not significant.

Method of drinking:

The method of drinking used by the child in relation to caries and rampant caries is shown in Table 4.52. There appeared to be little difference in the prevalence of caries and the way the drink was taken. Prevalence of caries ranged from 69% amongst those normally using a feeder cup to 74% amongst those using both cup with and without straw, but the differences were not statistically significant.

The prevalence of rampant caries was higher amongst those currently using a feeder cup (43%) compared to other methods (32%, 35% and 30%), but the difference again was not significant.

Fruits and food items:

The relationship between frequency of having selected fruits or food items and the prevalence of caries and rampant caries is summarised in Table 4.53 and 4.54.

Caries was highest amongst those who ate dates once or more often per day than amongst those who ate other fruit. Caries affected 336 children out of 426 (79%) who ate dates once daily or more.

The same was true for rampant caries, the prevalence was higher amongst those who consumed dates once daily or more often than amongst those who consumed dates less often (38% compared to 31%). The differences for other fruits were smaller.

Differences between those having fruits more and less often were not statistically significant except for that seen for dates which appeared to be highly significant for caries and significant for rampant caries and for grapes which appeared to be just significant for caries but not significant in relation to rampant caries.

No differences were seen in prevalence of caries between those having tomato ketchup, olives and pickles, fruit yoghurt and mayonnaise once or more often per day or less than that. The same was true for rampant caries (Table 4.54).

Iron and Vitamin C supplements:

The relationship between having iron or Vitamin C supplements and the prevalence of caries and rampant caries are shown in Table 4.55.

Forty four children (69%) out of 64 children having iron supplements had caries, and 20 (31%) had rampant caries. Differences between these and other children were not statistically significant for caries or for rampant caries.

Thirty four (63%) of the 54 of the children having Vitamin C had caries and 12 (22%) had rampant caries. Again differences between these and other children were not statistically significant for either caries or rampant caries.

Use of dummies dipped in honey or syrup:

Two hundred and fifteen of the 987 (22%) children who took part in the study had been given a dummy dipped in honey or sugary syrup (Table 4.56). Of these 190 (88%) had caries, compared to 528 (68%) of the 772 who had not done so. Of the group having dummies 125 (58%) children had rampant caries compared to 210 (27%) who had not used this form of comforter. The relationship between using dummies dipped in sugary syrup and caries was highly significant. The same was true for rampant caries.

Tooth brushing:

The relationship between oral hygiene habits of the children and caries and rampant caries is shown in Table 4.57.

Amongst those who brushed daily, 544 (71%) had caries and 248 (32%) had rampant caries. These values compared to 148 (82%) of those whose teeth were brushed occasionally who had caries and 73 (40%) who had rampant caries. This difference was statistically highly significant for caries and for rampant caries it was just significant.

Two hundred and fifty seven of the children had started to brush their teeth before the age of 12 months and 693 after the age of 12 months. Higher caries prevalence (76%) was seen when the habit started late compared to when it started earlier (65%). Oral hygiene habits in terms of the age at which the child started to brush their teeth showed a statistically significant relationship to both caries and rampant caries.

Five hundred and forty children were reported to brush with help on most occasions but 409 children brushed alone without help. Higher caries levels were seen when the child brushed alone without assistance (77% compared to 70%). The reverse was true for rampant caries (32% compared to 35%). The relation between brushing with help or alone and caries was statistically significant, but not that with rampant caries.

Multi-variate analysis

As for erosion multi-variate analysis was carried out using a stepwise multiple logistic regression to determine the strongest factors related to the outcomes of caries and rampant caries (Table 4.58 and 4.59).

More factors related to caries than erosion. The final model showed that factors related to aetiology of caries were using a dummy dipped in honey or a sugary syrup (OR=3.2), the consumption of fruit syrup when the child was a baby (OR=3.1), the frequency of use of diluted fruit syrup drinks at the current time (OR=2.1), school type (OR=1.9), the age at which the child start to brush his/her teeth (OR=1.8), the consumption of pure fruit juices at the time of the survey (OR=1.7), the mother's educational level (OR=1.6), whether the child brushed his/her teeth with help or without (OR=1.6) and the age of the child (OR=1.5).

The final model related to aetiology of rampant caries were using dummy dipped in sugary syrup (4.3), the use of Vitamin C (OR=2.3), school type (OR=2.1), mothers educational level (OR=1.7), frequent of use of fizzy drinks at current time (OR=1.7), time the child start to brush his/her teeth (OR=1.6), feeding type (OR=1.5), age of the child (OR=1.4).

Table 4.11 **Number and age of children included from private and public schools**

Age Group	Number & (%) of children		
	Private Schools	Public Schools	Total
3 yr	47 (7.3)	66 (19.1)	113 (11.4)
4 yr	245 (38.2)	214 (62.0)	459 (46.5)
5 yr	350 (54.5)	65 (18.8)	415 (42.0)
Total	642 (100)	345 (100)	987 (100)

SND for proportions aged 4 yr or less and 5 yr or more = 10.82 P<0.001
(95% confidence interval for difference = 0.29 - 0.42)

Table 4.12 **Numbers of children in relation to school type and fathers' occupation**

Fathers' Occupation	Number & (%) of children		
	Private Schools	Public Schools	Total
High Professionals	168 (26.2)	43 (12.5)	211 (21.4)
Professionals	92 (14.3)	33 (9.6)	125 (12.7)
Middle Class	272 (42.4)	189 (54.8)	461 (46.7)
Unskilled and Others	110 (17.1)	80 (23.2)	190 (19.2)
Total	642 (100)	345 (100)	987 (100)

(χ^2 for difference between occupation and school type = 35.42 P<0.001)

Table 4.13 **Numbers of children in relation to school type and level of mothers' education**

Level of Mothers' Education	Number & (%) of children		
	Private Schools	Public Schools	Total
College or Postgraduate	395 (61.5)	234 (67.8)	629 (63.7)
Secondary or High school	187 (29.1)	71 (20.6)	258 (26.1)
Primary and no education	4 (0.6)	7 (2.03)	11 (1.1)
Level not indicated	56 (8.7)	33 (9.6)	89 (9.0)
Total	642 (100)	345 (100)	987 (100)

(χ^2 for difference between level of mothers' education and school type = 11.67 P<0.01)

Table 4.14 **Relationship between gender of children, prevalence and severity of erosion**

		Number & (%) of children			
	No of Children	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
Male	511	342 (66.9)	169 (33.1)	110 (21.5)	59 (11.5)
Female	476	336 (70.6)	140 (29.4)	76 (16.0)	64 (13.4)
Total	987	678 (68.7)	309 (31.3)	186 (18.8)	123 (12.5)

Table 4.15 **Relationship between age of children, prevalence and severity of erosion**

		Number & (%) of children			
Age Group	**No of Children**	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
3 yr	113	82 (72.6)	31 (27.4)	17 (15.0)	14 (12.4)
4 yr	459	326 (71.0)	133 (29.0)	83 (18.1)	50 (10.9)
5 yr	415	270 (65.1)	145 (34.9)	86 (20.7)	59 (14.2)
Total	987	678 (68.7)	309 (31.3)	186 (18.8)	123 (12.5)

Table 4.16 **Prevalence of erosion in relation to school type and estimated age adjusted prevalence**

	Number & (%) of children		
	Private Schools	**Public Schools**	**Total**
No erosion	439 (68.4)	239 (69.3)	678 (68.7)
Any erosion	203 (31.6)	106 (30.7)	309 (31.3)
Total	642 (100)	345 (100)	987 (100)
Age adjusted prevalence	203 (31.6)	114 (33.4)	317 (32.1)

Table 4.17 **Number of children with caries and rampant caries in relation to school type**

Number & (%) of Children	Private Schools	Public Schools	Both Schools
Number in group	642	345	987
No (%) with Caries	454 (70.7)	266 (77.1)	720 (72.9)*
No (%) with Rampant Caries	199 (31.0)	137 (39.7)	336 (34.0) **

* SND for difference in proportions = 2.15 P<0.05
(95% confidence interval for difference = 0.057 to 0.12)

** SND for difference in proportions = 2.75 P<0.01
(95% confidence interval for difference = 0.025 to 0.149)

Table 4.18 **Mean (±SD) dmft and dmfs and components for children in relation to school type**

	Private Schools	Public Schools	Total
No of Children	642	345	987
Mean dmft (±) SD	4.41 (±4.64)	5.52 (±5.22)	4.80 (±4.87)*
dt	3.54 (±4.07)	4.76 (±4.78)	3.97 (±4.37)
mt	0.32 (±0.94)	0.32 (±1.03)	0.32 (±0.97)
ft	0.55 (±1.59)	0.43 (±1.46)	0.51 (±1.54)
Mean dmfs (±) SD	11.64 (±14.53)	14.60 (±16.91)	12.67 (±15.46)**
ds	8.72 (±11.90)	12.01 (±14.69)	9.87 (±13.03)
ms	1.3 (±3.83)	1.34 (±4.30)	1.33 (±3.99)
fs	1.60 (±5.18)	1.24 (±4.90)	1.48 (±5.09)

Mann-Whitney tests for differences
* dmft P = 0.002
** dmfs P = 0.009

Table 4.19 **Prevalence and severity of caries according to age group**

Age Group		Private Schools	Public Schools	Both
3 yr	**Number in Group**	47	66	113
	No (%) with caries	22 (47%)	47 (71%)	69 (61%)
	dmft (±) SD	2.30 (±3.80)	4.52 (±5.13)	3.59 (±4.74)
	dmfs (±) SD	5.60 (±11.01)	10.82 (±14.87)	8.64 (±13.59)
4 yr	**Number in Group**	245	214	459
	No (%) with caries	171 (70%)	164 (77%)	335 (73%)
	dmft (±) SD	4.19 (±4.48)	5.55 (±5.24)	4.82 (±4.89)
	dmfs (±) SD	10.71 (±13.37)	14.67(±17.11)	12.56(±15.33)
5 yr	**Number in Group**	350	65	415
	No (%) with caries	261 (75%)	55 (85%)	316 (76%)
	dmft (±) SD	4.85 (±4.77)	6.43 (±5.10)	5.09 (±4.85)
	dmfs (±) SD	13.10 (±15.46)	18.22 (±17.62)	13.90(±15.90)

Table 4.20 **Number of children with caries in relation to prevalence and severity of erosion**

		Number & (%) of children			
	No of Children	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
With Caries	720	483 (67.1)	237 (32.9)	142 (19.7)	95 (13.2)
Without Caries	267	195 (73.0)	72 (27.0)	44 (16.5)	28 (10.5)
Total	987	678 (68.7)	309 (31.3)	186 (18.8)	123 (12.5)

Table 4.21 **Number of children with rampant caries and in relation to prevalence and severity of erosion**

		Number & (%) of children			
	No of Children	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
With Rampant Caries	336	240 (71.4)	96 (28.6)	58 (17.3)	38 (11.3)
Without Rampant Caries	651	438 (67.3)	213 (32.7)	128 (19.7)	85 (13.1)
Total	987	678 (68.7)	309 (31.3)	186 (18.8)	123 (12.5)

Table 4.22 **Number of children with caries exclusive of those with rampant caries in relation to prevalence and severity of erosion**

		Number & (%) of children			
	No of Children	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
Without caries	267	195 (73.0)	72 (27.0)	44 (16.5)	28 (10.5)
With caries excluding rampant caries	384	243 (63.3)	141 (36.7)	84 (21.9)	57 (14.8)
With rampant caries	336	240 (71.4)	96 (28.6)	58 (17.3)	38 (11.3)
With any form of caries	720	483 (67.1)	237 (32.9)	142 (19.7)	95 (13.2)
Total	987	678 (68.7)	309 (31.3)	186 (18.8)	123 (12.5)

SND for difference in proportions with erosion and with and without caries (excluding rampant caries) = 2.61 $P < 0.01$
(95% confidence interval for differences in proportion = 0.024 to 0.17)

Table 4.23 **Prevalence and severity of erosion measured from photographs and clinically for 727 children**

	Number & (%) of children				
	With no erosion	**With any erosion**	**Erosion confined to score 1**	**Erosion confined to score 2**	**Erosion including score 3**
Photographic Scores	507 (69.7)	220 (30.3)	156 (21.5)	60 (8.3)	4 (0.6)
Clinical Scores	463 (63.7)	264 (36.3)	159 (21.9)	101 (13.9)	4 (0.6)

SND for difference in proportions with erosion using photographic and clinical scores = 2.45
P< 0.05 (95% confidence interval for difference = 0.012 to 0.109)
χ^2 for difference in severity of erosion = 379.951 P < 0.001

Table 4.24 **Prevalence of erosion in relation to tooth type and surface type affected measured from photographs and clinically for 727 children**

	Number of children					
	Teeth Affected			Surfaces Affected		
	Central incisors only	**Lateral incisors only**	**Both types of incisor**	**Palatal surfaces only**	**Buccal surfaces only**	**Both surface types**
Photographic Scores	151	3	66	217	0	3
Clinical Scores	155	4	105	258	0	6

Table 4.25 **Child prevalence and severity of erosion measured from photographs and clinically for 727 children**

		Number of Children				
		Clinical Scores				
		With no Erosion	**Erosion Score 1**	**Erosion Score 2**	**Erosion Score 3**	**Total**
Photo Scores	**With no Erosion**	439	49	19	-	507
	Erosion Score 1	21	104	31	-	156
	Erosion Score 2	3	6	51	-	60
	Erosion Score 3	-	-	-	4	4
	Total	463	159	101	4	727

kappa value=0.64

Table 4.26 **Tooth surface prevalence and severity of erosion in lateral and central incisors measured from photographs and clinically for 727 children**

		Number of Tooth Surfaces				
		Clinical Scores				
		With no Erosion	Erosion Score 1	Erosion Score 2	Erosion Score 3	Total
Photo Scores	With no Erosion	4576	165	36	-	4777
	Erosion Score 1	47	265	93	-	405
	Erosion Score 2	2	19	112	2	135
	Erosion Score 3	-	-	-	5	5
	Total	4625	449	241	7	5322

kappa value = 0.68
χ^2= 8236.33 P = 0.000

Table 4.27 **The relationship between fathers' occupation, prevalence and severity of erosion**

		Number & (%) of children			
Fathers' Occupation	**No of Children**	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score2 +**
High Professionals	211	151 (71.6)	60 (28.4)	37 (17.5)	23 (10.9)
Professionals	125	80 (64.0)	45 (36.0)	22 (17.6)	23 (18.4)
Middle class	461	312 (67.7)	149 (32.3)	96 (20.8)	53 (11.5)
Unskilled and Others	190	136 (71.6)	54 (28.4)	30 (15.9)	24 (12.7)
Total	987	679 (68.8)	308 (31.2)	185 (18.8)	123 (12.5)

Table 4.28 **The relationship between mothers' education, prevalence and severity of erosion**

		Number & (%) of children			
Mothers' Education	**No of Children**	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score2 +**
Primary and no education	11	8 (72.7)	3 (27.3)	1 (9.1)	2 (18.2)
Secondary and High School	258	174 (67.4)	84 (32.6)	47 (18.2)	37 (14.4)
College and Postgraduate	629	437 (69.5)	192 (30.5)	120 (19.1)	72 (11.4)
Total	898	619 (68.9)	279 (31.1)	168 (18.7)	111 (12.3)

Table 4.29 **The relationship between feeding type, prevalence and severity of erosion**

		Number & (%) of children			
	No of Children	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
Bottle	173	119 (68.8)	54 (31.2)	30 (17.3)	24 (13.9)
Breast	260	176 (67.7)	84 (32.3)	46 (17.7)	38 (14.6)
Both	554	383 (69.1)	171 (30.9)	110 (19.9)	61 (11.0)
Total	987	678 (68.7)	309 (31.3)	186 (18.8)	123 (12.5)

Table 4.30 **The relationship between feeding type and social class based on fathers' occupation**

		Number & (%) of children		
Fathers' Occupation	**No of Children**	**Bottle**	**Breast**	**Both**
High Professionals	211	19 (9.0)	53 (25.1)	139 (65.9)
Professionals	125	26 (28.8)	34 (27.2)	65 (52.0)
Middle class	461	77 (16.7)	129 (28.0)	255 (55.3)
Unskilled and Others	190	51 (26.8)	44 (23.2)	95 (50.0)
Total	987	173 (17.5)	260 (26.3)	554 (56.1)

($\chi^2$for difference between feeding type and social class = 25.73 P< 0.001)

Table 4.31 **The relationship between feeding type and social class based on mothers' education**

		Number & (%) of children		
Mothers' Education	**No of Children**	**Bottle**	**Breast**	**Both**
Primary and no education	11	2 (18.2)	3 (27.3)	6 (54.5)
Secondary and High School	258	40 (15.5)	87 (33.7)	131 (50.8)
College and Postgraduate	629	102 (16.2)	150 (23.8)	377 (59.9)
Total	898	144 (16.0)	240 (26.7)	514 (57.2)

($\chi^2$for difference between feeding type and mothers education 9.46 P=0.05)

Table 4.32 **The relationship between drinks from a feeding bottle when the child was a baby, prevalence and severity of erosion**

		Number & (%) of children			
Drink Type	**No of Children**	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
Pure Fruit Juice	608	416 (68.4)	192 (31.6)	118 (19.4)	74 (12.2)
Fruit Syrup*	56	31 (55.4)	25 (44.6)	17 (30.4)	8 (14.2)
Packed Fruit Juice***	95	58 (61.1)	37 (38.9)	17 (17.9)	20 (21.0)
Herbal Drinks**	580	413 (71.2)	167 (28.8)	99 (17.1)	68 (11.7)
One or more of the above	818	567 (69.3)	251 (30.7)	150 (18.3)	101 (12.3)
None of the above	169	111 (65.7)	58 (34.3)	36 (21.3)	22 (13.0)

* SND for difference in proportions with erosion and having and not having fruit syrup as a baby = 2.22 ($P< 0.05$) (95% confidence interval for difference = 0.0163 to 0.266)

** SND for difference in proportions with erosion and having and not having herbal as a baby = 2.03 ($P< 0.05$) (95% confidence interval for difference = 0.002 to 0.120)

*** χ^2 for difference in severity of erosion and having packed fruit juice =7.16 P=0.028

Table 4.33 **The relationship between bedtime drinks when the child was a baby, prevalence and severity of erosion**

		Number & (%) of children			
Drink Type	**No of Children**	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
Pure Fruit Juice	282	186 (66.0)	96 (34.0)	57 (20.2)	39 (13.8)
Fruit Syrup*	35	17 (48.6)	18 (51.4)	10 (28.6)	8 (22.9)
Packed Fruit Juice	74	44 (59.5)	30 (40.5)	18 (24.3)	12 (16.2)
Herbal Drinks	356	255 (71.6)	101 (28.4)	62 (17.4)	39 (11.0)
None of the above	278	190 (68.3)	88 (31.7)	53 (19.1)	35 (12.6)

*SND for difference in proportions with erosion and having and not having fruit syrup at bed time as a baby = 2.63 ($P< 0.01$)
(95% confidence interval for difference = - 0.054 to 0.366)

Table 4.34 **The relationship between bedtime drinks at the time of the study, prevalence and severity of erosion**

		Number & (%) of children			
Drink Type	**No of Children**	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
Pure Fruit Juice	144	94 (65.3)	50 (34.7)	28 (19.4)	22 (15.3)
Fruit Syrup*	65	36 (55.4)	29 (44.6)	16 (24.6)	13 (20.0)
Packed Fruit Juice	108	69 (63.9)	39 (36.1)	24 (22.2)	15 (13.9)
Herbal Drinks	15	9 (60.0)	6 (40.0)	6 (40.0)	0
Fizzy drinks	90	60 (66.7)	30 (33.3)	16 (17.8)	14 (15.6)
Non of these drinks	648	445 (68.7)	203 (31.3)	124 (19.1)	79 (12.2)

*SND for difference in proportions with erosion and having /and not having fruit syrup at bedtime currently = 2.36 ($P< 0.05$)
(95% confidence interval for difference = 0.024 to 0.258)

Table4.35 **The relationship between frequency of potentially erosive drinks, prevalence and severity of erosion**

			Number & (%) of children			
Drinks	**Frequency**	**No of Children**	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
Pure fruit juice	Never or 1-2 times/week	135	92 (68.1)	43 (31.9)	27 (20.0)	16 (11.9)
	1 or more/day	785	544 (69.3)	241 (30.7)	147 (18.7)	94 (12.0)
Fizzy drink*	Never or 1-2 times/week	496	358 (72.2)	138 (27.8)	91 (18.3)	47 (9.5)
	1 or more/day	397	252 (63.5)	145 (36.5)	84 (21.2)	61 (15.4)
Diluted fruit syrup**	Never or 1-2 times/week	730	512 (70.1)	218 (29.9)	137 (18.8)	81 (11.1)
	1 or more/day	154	95 (61.7)	59 (38.3)	36 (23.4)	23 (14.9)

*SND for difference in proportions with erosion and having fizzy drinks once or more per day and once or less per week currently = 2.77 ($P < 0.01$) (95% confidence interval for difference = 0.025 to 0.148)

**SND for difference in proportions with erosion and having diluted fruit syrup once or more per day and once or less per week currently = 2.05 ($P < 0.05$) (95% confidence interval for difference = 0.004 to 0.167)

Table 4.36 **The relationship between using cup with/without straw, prevalence and severity of erosion**

		Number & (%) of children			
Methods of drinking	**No of Children**	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score2 +**
Feeder cup	73	51 (69.9)	22 (30.1)	15 (20.5)	7 (9.6)
Cup with straw	79	52 (65.8)	27 (34.2)	19 (24.1)	8 (10.1)
Cup without straw	519	356 (68.6)	163 (31.4)	107 (20.6)	56 (10.8)
Both with and without straw	301	206 (68.4)	95 (31.6)	44 (14.6)	51 (16.9)
Total	972	665 (68.4)	307 (31.6)	185 (19.0)	122 (12.6)

Table 4.37 **The relationship between consumption of specific fruits, prevalence and severity of erosion**

			Number & (%) of children			
Fruits	**Frequency**	**No of Children**	**With no erosion**	**With any erosion**	**Erosion scores confined to score 1**	**confined to score 2 +**
Apples	Never or 1-2 times/week	278	193 (69.4)	85 (30.6)	49 (17.6)	36 (12.9)
	1 or more/day	687	472 (68.7)	215 (31.3)	133 (19.4)	82 (11.9)
Oranges	Never or 1-2 times/week	298	208 (69.8)	90 (30.2)	54 (18.1)	36 (12.1)
	1 or more/day	664	454 (68.4)	210 (31.6)	129 (19.4)	81 (12.2)
Others	Never or 1-2 times/week	203	140 (69.0)	63 (31.0)	36 (17.7)	27 (13.3)
	1 or more/day	485	341 (70.3)	144 (29.7)	92 (19.0)	52 (10.7)
Dates	Never or 1-2 times/week	537	371 (69.1)	166 (30.9)	102 (19.0)	64 (11.9)
	1 or more/day	426	294 (69.0)	132 (31.0)	81 (19.0)	51 (12.0)
Grapefruit	Never or 1-2 times/week	941	650 (69.1)	291 (30.9)	175 (18.6)	116 (12.3)
	1 or more/day	22	12 (54.5)	10 (45.5)	8 (36.4)	2 (9.1)
Grapes	Never or 1-2 times/week	562	383 (68.1)	179 (31.9)	103 (18.3)	76 (13.5)
	1 or more/day	381	269 (70.6)	112 (29.4)	74 (19.4)	38 (10.0)

Table 4.38 **The relationship between consumption of specific food items, prevalence and severity of erosion**

			Number & (%) of children			
Food items	**Frequency**	**No of Children**	**With no erosion**	**With any erosion**	**Erosion scores confined to score 1**	**confined to score 2 +**
Tomato ketchup	Never or 1-2 times/week	368	263 (71.5)	105 (28.5)	64 (17.4)	41 (11.1)
	1 or more/day	591	399 (67.5)	192 (32.5)	118 (20.0)	74 (12.5)
Olives & Pickles	Never or 1-2 times/week	758	529 (69.8)	229 (30.2)	142 (18.7)	87 (11.5)
	1 or more/day	202	133 (65.8)	69 (34.2)	41 (20.3)	28 (13.9)
Fruit yoghurt	Never or 1-2 times/week	531	376 (70.8)	155 (29.2)	93 (17.5)	62 (11.7)
	1 or more/day	433	290 (67.0)	143 (33.0)	90 (20.8)	53 (12.2)
Mayonnaise	Neveror 1-2 times/week	788	554 (70.3)	234 (29.7)	144 (18.3)	90 (11.4)
	1 or more/day	177	113 (63.8)	64 (36.2)	40 (22.6)	24 (13.6)

Table 4.39 **The relationship between taking Iron and Vitamin C supplements, prevalence and severity of erosion**

		Number & (%) of children			
	No of Children	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score 2 +**
Taking Iron supplements	64	46 (71.9)	18 (28.1)	9 (14.1)	9 (14.1)
Not taking Iron supplements	923	632 (68.5)	291 (31.5)	177 (19.2)	114 (12.4)
Taking Vit C supplements*	54	26 (48.1)	28 (51.9)	14 (25.9)	14 (25.9)
Not taking Vit C supplements	933	652 (69.9)	281 (30.1)	172 (18.4)	109 (11.7)

SND for difference in proportions with erosion and having /not having Vitamin C supplements = 3.35 P< 0.001
(95% confidence interval for differences in proportion = 0.090 to 0.344)
* (χ^2 for differences in prevalence of erosion = 13.34 P = 0.001)

Table 4.40 **The relationship between using dummies dipped in honey or sugary syrup and prevalence and severity of erosion**

		Number & (%) of children			
	No of Children	**With no erosion**	**With any erosion**	**Erosion Scores confined to score 1**	**confined to score2 +**
Using Dummies	215	151 (70.2)	64 (29.8)	34 (15.8)	30 (14.0)
Not Using Dummies	772	528 (68.4)	244 (31.6)	152 (19.7)	92 (11.9)

Table 4.41 **The relationship between prevalence and severity of erosion and brushing frequency, age at starting to brush and brushing with or without help**

	Frequency		Starting Time		With/Without Help	
	1 or more/day	Occasionally	0-12 months	>12 months	With Help	Without Help
No of Children (Total)	768	181	257	693	540	409
With no erosion (No &%)	530 (69.0)	122 (67.4)	178 (69.3)	475 (68.5)	374 (69.3)	278 (68.0)
With erosion (No &%)	238 (31.0)	59 (32.6)	79 (30.7)	218 (31.5)	166 (30.7)	131 (32.0)

Table 4.42 **Results of logistic regression for erosion when all children included: regression coefficient (B), standard error (S.E), significance (P), odds ratio (OR) with 95% CI for OR**

Variable*	B	S.E.	Sig	OR	95%CI for OR Lower	Upper
Use of Vit C*1	.9638	.2958	.001	2.6215	1.4681	4.6811
Fruit syrup at bedtime*2	.8577	.3555	.0158	2.3577	1.1746	4.7326
Frequency of fizzy drinks *4	.3526	.1468	.0163	1.4227	1.0671	1.8969

Table 4.43 **Results of logistic regression for erosion when children with rampant caries were excluded: regression coefficient (B), standard error (S.E), significance (P), odds ratio (OR) with 95% CI for OR**

Variable*	B	S.E.	Sig	OR	95%CI for OR Lower	Upper
Use of Vit C*1	.9676	.2977	.001	2.6317	1.4684	4.7168
Fruit syrup at bedtime*2	.8266	.3575	.021	2.2855	1.1342	4.6053
Caries excluding rampant caries *3	.4273	.1496	.004	1.5332	1.1435	2.0556
Frequency of fizzy drinks *4	.3805	.1479	.010	1.4629	1.0949	1.9548

Coding used

*1 Use of Vitamin C
1 = not having Vitamin C
2 = having Vitamin C

*2 Diluted fruit syrup at bed time as a baby
1 = not having diluted fruit syrup at bed time
2 = having diluted fruit syrup at bed time

*3 Caries
0 = no caries
1 = caries excluding rampant caries

*4 Frequency of fizzy drinks at the time of the study
1= once or twice/week
2 = once a day or more

Table 4.44 **The relationship between social class based on fathers' occupation, caries and rampant caries**

		Number & (%) of children	
Fathers' Occupation	**No of Children**	**With Caries***	**With Rampant Caries**
High Professionals	211	138 (65.4)	59 (28.0)
Professionals	125	95 (76.0)	44 (35.2)
Middle class	461	341 (74.0)	166 (36.0)
Unskilled &Others	190	146 (76.8)	67 (35.3)
Total	987	720 (72.9)	336 (34.0)

* (χ^2 for difference in prevalence of caries = 8.38 $P < 0.01$)

Table 4.45 **The relationship between social class based on mothers' education, caries and rampant caries**

		Number & (%) of children	
Level of Mothers' Education	**No of Children**	**With Caries***	**With Rampant Caries****
College and Postgraduate	629	441 (70.1)	191 (30.4)
Secondary and High School	258	209 (81.0)	111 (43.0)
Primary and no education	11	10 (90.9)	7 (63.6)
Total	898	660 (73.5)	309 (34.4)

* (χ^2 for difference in prevalence of caries = 12.89 $P< 0.01$)
** (χ^2 for difference in prevalence of rampant caries = 17.20 $P< 0.001$)

Table 4.46 **The relationship between feeding type, prevalence of caries and rampant caries**

Feeding Type		Number & (%) of children	
	No of Children	With Caries*	With Rampant Caries**
Bottle	173	113 (65.3)	46 (26.6)
Breast	260	199 (76.5)	105 (40.4)
Both	554	408 (73.6)	185 (33.4)
Total	987	720 (72.9)	336 (34.0)

* (χ^2 for difference in prevalence of caries = 6.94 P<0.01)
** (χ^2 for difference in prevalence of rampant caries = 9.04 P=0.01)

Table 4.47 **The relationship between duration of breast feeding, prevalence of caries and rampant caries**

		Number & (%) of children	
Duration of breast feeding	No of Children	With Caries*	With Rampant Caries
2 weeks - 4 months	194	131 (67.5)	64 (33.1)
4 months - 6 months	107	79 (73.8)	31 (29.1)
6 months -1 year	152	120 (78.9)	51 (33.6)
1 year - ≥ 2 years	181	145 (80.1)	78 (43.1)
No answer	180	---	---
Total	814	475	224

* (χ^2 for difference in prevalence of caries = 9.62 P=0.022)

Table 4.48 **The relationship between drinks from a feeding bottle when the child was a baby, prevalence of caries and rampant caries**

Drink Type	No of Children	Number & (%) of children	
		With Caries	With Rampant Caries
Pure Fruit Juice	608	442 (72.7)	202 (33.2)
Fruit Syrup	56	46 (82.1)	21 (37.5)
Packed Fruit Juice	95	73 (76.8)	33 (34.7)
Herbal Drinks	580	421 (72.6)	187 (32.2)
One or more of the above	818	590 (72.1)	265 (32.4)
None of the above	169	130 (76.9)	71 (42.0)

Table 4.49 **The relationship between bedtime drinks given as a baby, prevalence of caries and rampant caries**

Drink Type	No of Children	Number & (%) of children	
		With Caries	With Rampant Caries
Pure Fruit Juice	282	212 (75.2)	108 (38.3)
Fruit Syrup	35	28 (80.0)	11 (31.4)
Packed Fruit Juice*	74	60 (81.1)	33 (44.6)
Herbal Drinks	356	258 (72.5)	121 (34.0)
None of the above	278	202 (72.7)	96 (34.5)

* SND for difference in proportions with rampant caries and having / not having packed fruit juice = 1.99 ($P< 0.05$)
(95% confidence interval for difference = 0.002 to 0.226)

Table 4.50 **The relationship between bedtime drinks at the time of the study, prevalence of caries and rampant caries**

Drink Type	No of Children	Number & (%) of children With Caries	With Rampant Caries
Pure Fruit Juice	144	116 (80.6)	54 (37.5)
Fruit Syrup	65	54 (83.1)	26 (40.0)
Packed Fruit Juice	108	91 (84.3)	47 (43.5)
Herbal Drinks	15	9 (60.0)	3 (20.0)
Fizzy drinks	90	75 (83.3)	41 (45.6)
None of these drinks	648	462 (71.3)	213 (32.9)

SND for difference in proportions with caries and having / not having pure fruit juice at bedtime currently = 2.26 ($P< 0.05$)
(95% confidence interval for difference = 0.012 to 0.169)

SND for difference in proportions with caries and having / not having fruit syrup at bedtime currently = 4.82 ($P< 0.001$)
(95% confidence interval for difference = 0.065 to 0.155)

SND for difference in proportions with caries and having / not having packed fruit juice at bedtime currently = 2.83 ($P< 0.01$)
(95% confidence interval for difference = 0.039 to 0.217)

SND for difference in proportions with caries and having / not having fizzy drinks at bedtime currently = 2.34 ($P< 0.05$)
(95% confidence interval for difference = 0.053 to 0.211)

SND for difference in proportions with rampant caries and having / not having fizzy drinks at bedtime currently = 2.39 ($P< 0.05$)
(95% confidence interval for difference = 0.022 to 0.228)

SND for difference in proportions with rampant caries and having / not having packed fruit juice at bedtime currently = 2.18 ($P< 0.05$)
(95% confidence interval for difference = 0.010 to 0.200)

Table 4.51 **The relationship between frequency of having certain drinks, caries and rampant caries**

			Number & (%) of children	
Drinks	**Frequency**	**No of Children**	**With Caries**	**With Rampant Caries**
Pure fruit juice	Never or 1-2 times/week	135	100 (74.1)	42 (31.1)
	1 or more/day	785	564 (71.8)	265 (33.8)
Fizzy drinks	Never or 1-2 times/week	496	342 (69.0)	138 (27.8)
	1 or more/day	397	300 (75.6)	159 (40.1)
Diluted fruit syrup	Never or 1-2 times/week	730	508 (69.6)	229 (31.4)
	1 or more/day	154	126 (81.8)	60 (39.0)

SND for difference in proportions with caries and having fizzy drinks once or more per day and once or less per week currently = 2.18 ($P< 0.05$)
(95% confidence interval for difference = 0.006 to 0.12)

SND for difference in proportions with caries and having diluted fruit syrup once or more per day and once or less per week currently = 3.06 ($P< 0.01$)
(95% confidence interval for difference = 0.044 to 0.200)

SND for difference in proportions with rampant caries and having fizzy drinks once or more per day and once or less per week currently = 3.85 ($P< 0.001$)
(95% confidence interval for difference = 0.060 to 0.184)

Table 4.52 **The relationship between using cup with/without straw, caries and rampant caries**

Method of drinking		Number & (%) of children	
	No of Children	**With Caries**	**With Rampant Caries**
Feeder cup	73	50 (68.5)	31 (42.5)
Cup with straw	79	56 (70.9)	25 (31.6)
Cup without straw	519	376 (72.4)	182 (35.1)
Both with and without straw	301	224 (74.4)	91 (30.2)
Total	972	706 (72.6)	329 (33.8)

Table 4.53 **The relationship between consumption of specific fruits and caries and rampant caries**

			Number & (%) of children	
Fruits	**Frequency**	**No of Children**	**With Caries**	**With Rampant Caries**
Apples	Never or 1-2 times/week	278	200 (71.9)	94 (33.8)
	1 or more/day	687	505 (73.5)	234 (34.1)
Oranges	Never or 1-2 times/week	298	212 (71.1)	106 (35.6)
	1 or more/day	664	491 (73.9)	221 (33.3)
Others	Never or 1-2 times/week	203	143 (70.4)	68 (33.5)
	1 or more/day	485	357 (73.6)	155 (32.0)
Dates*	Never or 1-2 times/week	537	368 (68.5)	165 (30.7)
	1 or more/day	426	336 (78.9)	163 (38.3)
Grapefruit	Never or 1-2 times/week	941	691 (73.4)	318 (33.8)
	1 or more/day	22	13 (59.1)	8 (36.4)
Grapes**	Never or 1-2 times/week	562	422 (75.1)	191 (34.0)
	1 or more/day	381	263 (69.0)	127 (33.3)

* SND for difference in proportions with caries and eating dates once or more per day and once or less per week currently = 3.59 ($P < 0.001$)
(95% confidence interval for difference = 0.047 to 0.159)
SND for difference in proportions with rampant caries and eating dates once or more per day and once or less per week currently = 2.45 ($P < 0.05$)
(95% confidence interval for difference = 0.015 to 0.135)

** SND for difference in proportions with caries and eating grapes once or more per day and once or less per week currently = 2.04 ($P < 0.05$)
(95% confidence interval for difference = 0.002 to 0.118)

Table 4.54 **The relationship between consumption of specific food items, caries and rampant caries**

			Number & (%) of children	
Food items	**Frequency**	**No of Children**	**With Caries**	**With Rampant Caries**
Tomato ketchup	Never or 1-2 times/week	368	262 (71.2)	118 (32.1)
	1 or more/day	591	437 (73.9)	211 (35.7)
Olives and Pickles	Never or 1-2 times/week	758	554 (73.1)	262 (34.6)
	1 or more/day	202	145 (71.8)	64 (31.7)
Fruit yoghurt	Never or 1-2 times/week	531	391 (73.6)	186 (35.0)
	1 or more/day	433	312 (72.1)	143 (33.0)
Mayonnaise	Never or 1-2 times/week	788	571 (72.5)	261 (33.1)
	1 or more/day	177	134 (75.7)	68 (38.4)

Table 4.55 **The relationship between taking Iron and Vitamin C supplements, caries and rampant caries**

		Number & (%) of children	
	No of Children	With Caries	With Rampant Caries
Taking Iron supplements	64	44 (68.8)	20 (31.3)
Not taking Iron supplements	923	676 (73.2)	316 (34.2)
Taking Vitamin C supplements	54	34 (63.0)	12 (22.2)
Not taking Vitamin C supplements	933	686 (73.5)	324 (34.8)

Table 4.56 **The relationship between using dummies dipped in honey or sugary syrup, caries and rampant caries**

		Number & (%) of children	
	No of children	With Caries*	With Rampant Caries**
Using Dummies	215	190 (88.4)	125 (58.1)
Not Using Dummies	772	528 (68.4)	210 (27.2)

SND for difference in proportions with caries and using/not using dummies dipped in sugary syrup = 5.81 (P< 0.001)
(95% confidence interval for difference = 0.132 to 0.267)

SND for difference in proportions with rampant caries and using/not using dummies dipped in sugary syrup = 8.47 (P< 0.001)
(95% confidence interval for difference = 0.237 to 0.380)

* (χ^2 for difference in prevalence of caries = 33.35 P=0.000)

** (χ^2 for difference in prevalence of rampant caries = 71.35 P=0.000)

Table 4.57 **The relationship between prevalence of caries and rampant caries and brushing frequency, age at starting to brush and brushing with or without help**

	Frequency *		Starting Time**		With/Without Help***	
	1 or more/day	Occasion	0-12 months	>12 months	With Help	Without Help
No of Children (Total)	768	181	257	693	540	409
With Caries (No &%)	544 (70.8)	148 (81.8)	166 (64.6)	527 (76.0)	378 (70.0)	314 (76.8)
With Rampant Caries (No &%)	248 (32.3)	73 (40.3)	70 (27.2)	251 (36.2)	190 (35.2)	131 (32.0)

* SND for difference in proportions with caries and brushing daily/occasionally = 2.98 ($P< 0.01$) (95% confidence interval for difference = 0.037 to 0.181)

SND for difference in proportions with rampant caries and brushing daily/occasionally = 2.06 ($P< 0.05$) (95% confidence interval for difference = 0.004 to 0.157)

**SND for difference in proportions with caries and starting to brush less than I year/or later = 3.53 ($P< 0.001$) (95% confidence interval for difference = 0.051 to 0.178)

SND for difference in proportions with rampant caries and starting to brush < I year/or later = 2.60 ($P< 0.01$) (95% confidence interval for difference = 0.022 to 0.158)

***SND for difference in proportions with caries and brushing with/without assistance = 2.33 ($P< 0.05$) (95% confidence interval for difference = 0.011to 0.125)

Table 4.58 **Results of logistic regression for caries: regression coefficient (B), standard error (S.E), significance (P), odds ratio (OR) with 95% CI OR**

Variable*	B	S.E.	Sig	OR	95%CI for OR	
					Lower	Upper
Use of dummy*1	1.1537	.2582	.000	3.1700	1.9112	5.2578
Fruit syrup as a baby*2	1.1410	.5473	.037	3.1300	1.0707	9.1501
Frequency of fruit syrup*3	.7258	.2683	.007	2.0664	1.2213	3.4964
School type*4	.6547	.1979	.001	1.9246	1.3058	2.8367
Start brushing*5	.5727	.1835	.002	1.7730	1.2373	2.5406
Current use of Pure juice at bedtime *6	.5469	.2654	.039	1.7278	1.0271	2.9065
Mothers educational level*7	.4896	.1977	.013	1.6317	1.1075	2.4041
Brushing with help*8	.4438	.1763	.012	1.5586	1.1034	2.2017
Age*9	.4092	.1340	.002	1.5056	1.1579	1.9577

Table 4.59 **Results of logistic regression for rampant caries: regression coefficient (B), standard error (S.E), significance (P), odds ratio with 95% CI**

Variable	B	S.E.	Sig	OR	95%CI for OR	
					Lower	Upper
Use of dummy*1	1.4550	.1899	.000	4.2843	2.9529	6.2159
Use of Vit C*10	.8180	.4002	.041	2.2659	1.0341	4.9648
School type*4	.7344	.1846	.000	2.0842	1.4514	2.9930
Mothers educational level*7	.5539	.1731	.001	1.7400	1.2393	2.4430
Frequency of fizzy drinks*12	.5160	.1626	.002	1.6754	1.2182	2.3043
Start brushing*5	.4570	.1915	.017	1.5793	1.0852	2.2985
Feeding type*11	.4158	.1816	.022	1.5156	1.0617	2.1636
Age*9	.3018	.1354	026	1.3522	1.0371	1.7631

Coding used

*1 Use of sweetened dummy
1 = not using sweetened dummy
2 = using sweetened dummy

*2 Dilute fruit syrup as a baby
1 = not having diluted fruit syrup as a baby
2 = having diluted fruit syrup as a baby

*3 Frequency of fruit syrup at the time of the study
1 = once or twice/ week
2 = once a day or more

*4 School type
1 = private 2 = public

*5 Start brushing
1 = 0-1year 2 = 1-2 year

*6 Currently use of pure juice drink at bed time
1 = not having pure fruit juice at bed time
2 = having pure juice at bed time

*7 Mothers educational level
1 = college and beyond
2 = others

*8 Brushing with help
1= with help
2 = with out help

*9 Age
1 = 3 yr old, 2 = 4 yr old, 3 = 5 yr old

*10 Use of Vitamin C
1= not having Vitamin C
2= having Vitamin C

*11 Feeding type
1 = no breast feeding or both breast and bottle
2 = breast feeding only

*12 Frequency of fizzy drinks at the time of the study
1 = once or twice/ week 2 = once a day or more

Figure 5: Prevalence of Erosion in Relation to Frequency of Current Drinks

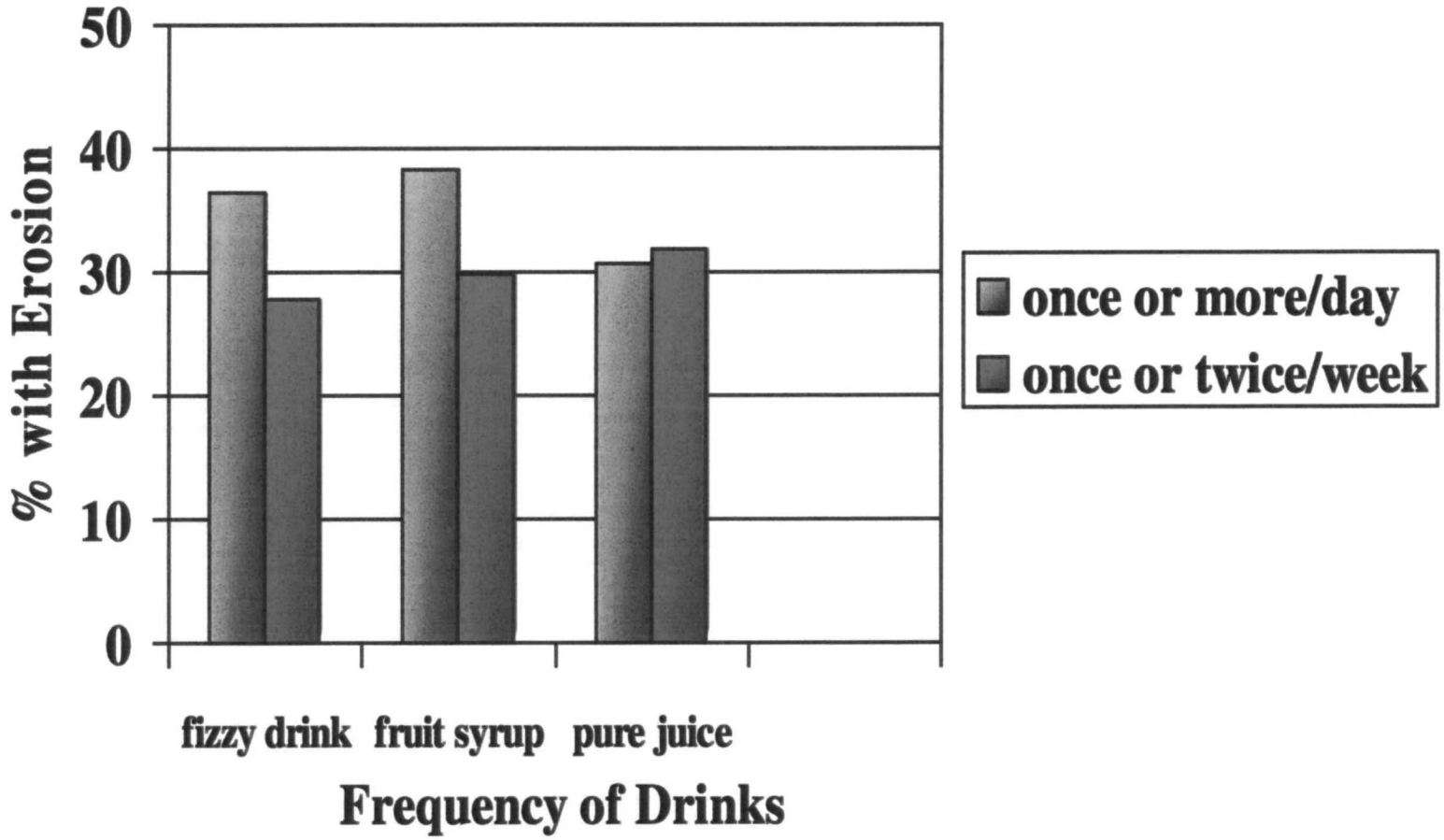


Figure 6: Prevalence of Erosion in Relation to Taking Vitamin C Supplements

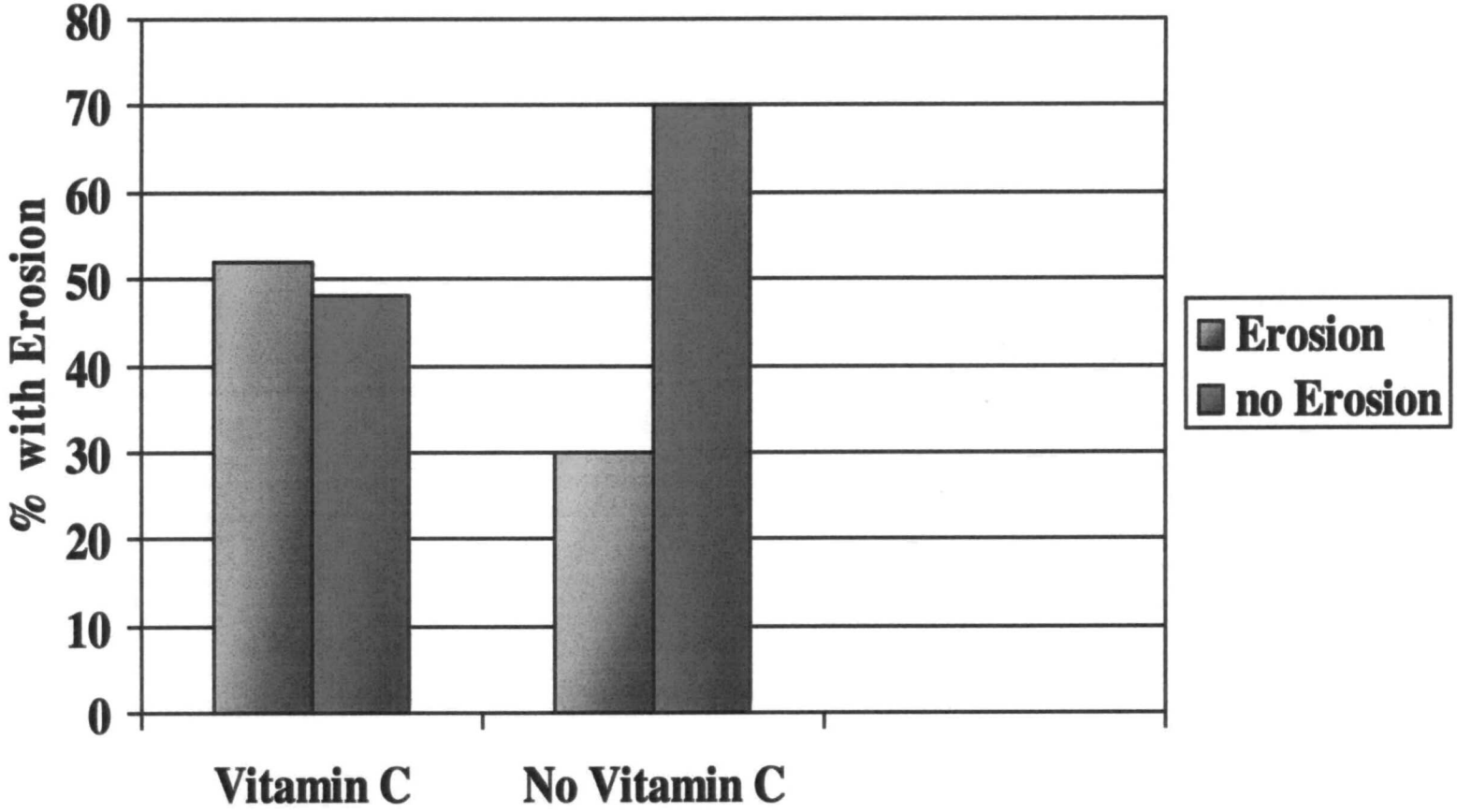
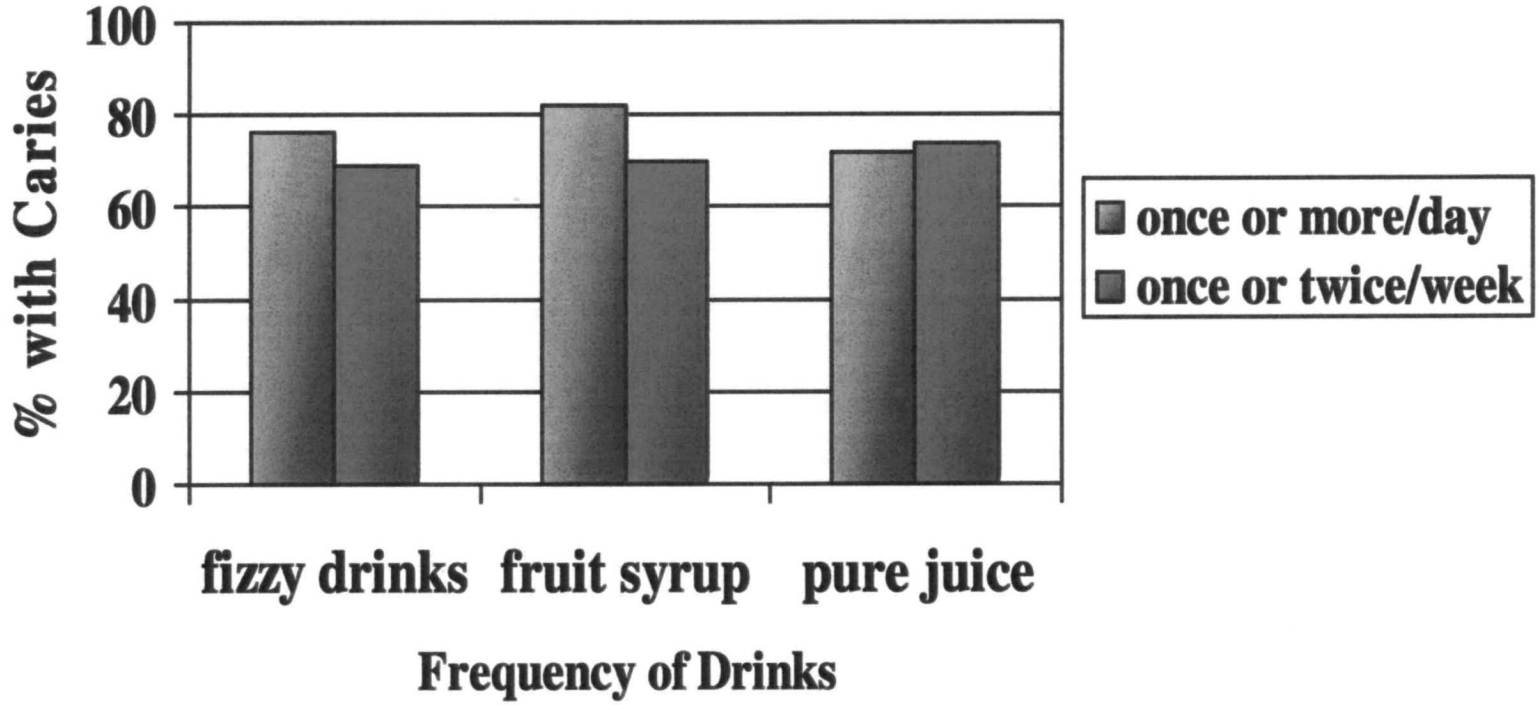


Figure 7: Prevalence of Caries in Relation to Frequency of Current Drinks



CHAPTER FIVE

DISCUSSION

5.1 Study of exfoliated and extracted teeth

5.1.1 Introduction

Case reports of erosion have appeared in the literature for more than 50 years (Stafne & Lovestedt 1947, Allan 1967, Fuller & Johnson 1977, Reuter 1978), but the condition has received much more attention in the last two decades. Erosion may have little impact but once it has progressed to involve dentine, it may result in sensitivity, loss of pulp vitality and abscess formation. These consequences may occur in erosion of either primary or permanent teeth but they may potentially arise more rapidly in the case of primary teeth because the layer of enamel to be eroded before dentinal exposure is thinner.

Recent studies have suggested that the prevalence of erosion in primary teeth is relatively high, but measurement has proved difficult. Reproducibility of measurement has not always been good and validity of measurement has been little studied.

Erosion has been measured in animal and in laboratory studies, where methods may be more objective, but these may not reflect the condition that occurs clinically. In vivo, the loss of tooth tissue may represent the outcome of a complex process involving saliva, susceptible tooth surfaces and acid from one or several sources. One of the major problems in measurement lies in clinical detection of early signs of erosive wear but difficulties also arise because of the likely concurrent processes of abrasion and attrition, which may all contribute to the observed loss of tooth tissue.

The first part of this study was designed to investigate the validity of a simple index to assess wear in primary teeth. The index chosen was based on that used in large epidemiological study in the U K. It was used at visual inspection and on photographs of the teeth.

A sample of exfoliated or extracted teeth was included and the condition of the teeth on ground section was chosen as the gold standard. The study was confined to upper anterior teeth, since these are the teeth that have been most often studied and are the most accessible for both clinical examination and photography in the young child. The sample of the teeth were scored as to the presence/absence of tissue loss and the extent of loss.

5.1.2 Advantages and disadvantages of the method

The method used possessed both advantages and drawbacks. Using exfoliated and extracted teeth made it easy to standardise conditions for examination and photography, avoiding the need for clinical examination with its inherent constraints of time and co-operation. The method also allowed teeth to be sectioned and submitted to microscopic examination. At the same time, use of photographs had the advantage of providing a permanent record, which could be easily and repeatedly examined by the same or different examiners before or after sectioning.

Major disadvantages of the method included the fact that the examining conditions differed from those occurring at a clinical examination. Extracted teeth are also unlikely to form a representative sample. The history and likely aetiology of any erosion present is also likely to be unknown for many teeth collected in this manner. It is also of note that in this study it proved difficult to collect a sample of suitable teeth. In all 100 were collected, only 41 of which were suitable. Others were rejected as a consequence of extensive caries, restorations or fractures reflecting other problems in the population of children from whom they were derived.

Results of repeated examinations suggested good reproducibility in use of the index, with kappa estimates ranging from 0.77 for the photographic to 0.96 for direct visual examination.

Agreement between scores and histological appearance was also high, suggesting reasonable validity, with a sensitivity of 0.94 and specifity of 1.0 for both visual and photographic methods of use of the index.

However, although the index showed good reproducibility and validity under these 'ideal' conditions, it also underestimated the extent of erosion in 12 of 33 cases when it was present. If this finding were to be confirmed, it may indicate that more extensive forms of erosion/wear are more prevalent than has been suggested in previous studies.

5.1.3 Differentiation between erosion, attrition and abrasion

In the present study, scoring was related to tooth wear and no direct attempt was made to differentiate between erosion, attrition or abrasion. However, at clinical, photographic and histological examination a note was made of the surfaces affected and the shape of the lesion was recorded.

Some authors have postulated that the effects of these three process cannot be distinguished particularly in their early stages (Smith &Knight 1984, Lewis &Smith 1973, Nunn et al 1996) and some indices, including the widely used Smith &Knight index and the one used here, are based on this assumption. There have, nevertheless, been suggestions that there are differences and that the three can be distinguished not only by the history but also by the site affected and in clinical appearance and the shape of lesions (Johnson & Sivers 1987, Asher &Read 1987, Nunn et al 1996 and Bishop 1997).

A histologically distinct appearance has also been described (Smith & Shaw 1987, Grando et al 1996).

1) Sites affected

Theoretically, erosion may affect any tooth or tooth surface. It has been suggested to affect particularly palatal or lingual surfaces (Johnson & Sivers 1987). In this study, wear affected 19 palatal surfaces (46%) and no buccal surfaces were affected, a result perhaps primarily suggestive of erosion in at least some cases.

In terms of site, attrition is believed to occur more often on incisal, occlusal and lingual surfaces of upper anterior and/or labial surfaces of lower anterior teeth as a result of tooth-to-tooth contact. In the current study, in 27 of the 31 cases with visible tooth wear, wear also affected incisal edges or cusp tips. In only 4 cases was loss confined to palatal surfaces and in 15 it involved both incisal and palatal surfaces. Thus, part of the tooth tissue loss even in a proportion of cases where the site suggested it to have been erosive, could have been a consequence of attrition.

2) Clinical appearance and the shape of the lesions

Erosion is described as resulting in loss of normal enamel contour, including loss of developmental ridges on enamel, and a smooth glazed enamel surface. This appearance was seen in the current study, where loss of contour was seen in all affected teeth.

Subjective assessment of loss of contour may be difficult in its early stages but in this study good reproducibility was achieved both within and between examiners and for

both photography and visual inspection. In contrast to erosion, where rounded margins are apparent, attrition is described as resulting in lesions with "knife edges".

In this study, no "knife edge" lesions were evident, suggesting perhaps that even where attrition had affected incisal edges, loss of tooth tissue might have been at least partly a consequence of erosion even in these areas. It may be concluded that in the current study, neither the site of loss nor the appearance of remaining tooth tissue gave clear indications of a single cause for tooth wear in the sample of teeth.

3) Histological appearance

The histological appearance of tooth wear has been studied in experimentally induced erosion. Incubation of teeth in acidic solutions such as fruit juices under experimental conditions induced erosion (Smith&Shaw1987) gave rise to lesions of 'white spot' macroscopic appearance. The surface of the lesions was chalky and opaque, in contrast to the adjacent, sound enamel. Sections of these teeth viewed under polarised light conditions showed appreciable destruction of the enamel surface. Complete loss of surface enamel had taken place and the lesion surface appeared irregular. Beneath the surface, there was a zone of the enamel which had a translucent appearance under polarised light, reminiscent of the translucent zone seen in early enamel caries. However, the macroscopic appearance of the lesions was one of gross demineralisation. The translucent appearance of the enamel beneath the lesion surface suggested that diffusion of the juice into the enamel had occurred, giving rise to partial dissolution of the tissues (Smith & Shaw 1987).

In the current study, tooth wear was recorded on microscopic examination of ground sections. As in the reports of Smith & Shaw, an irregular surface was seen and partial or complete loss of enamel was obvious. However there was no evidence of a subsurface translucent zone. Where diffuse demineralisation was visible adjacent to an area of tooth wear this was particularly regarded as being a consequence of erosion. However only 11 of the 33 cases showing loss of tooth tissue demonstrated this characteristic feature of diffuse demineralisation suggestive of chemical action, in others there was simply a loss of surface or an irregular surface with simple demineralisation evident on the labial or palatal surface and/or secondary dentine formation.

In experimental studies, teeth had been experimentally exposed to low pH solutions such as drinks, in order to induce erosion. In vitro situations may greatly exaggerate the erosive effects of dietary items because of a lack of protective factors such as saliva (with its attendant buffering capacity, continuous flow and pH, calcium and phosphorous content), salivary pellicle and fluoride. All of these may modify the effect of acid on enamel mineral. The in vitro conditions also do not allow for interaction between erosive, abrasion and attrition. In vivo, demineralised areas of enamel may have been lost through abrasion or attrition during normal function over a period of time. This has been shown experimentally in the past (Sorvari et al 1996).

Thus, unless active erosion had occurred just before the tooth was lost, characteristic demineralisation may well not be apparent.

5.1.4 The relationship between erosion and caries

Although the mechanism of tooth tissue destruction in erosion and caries is similar, with both involving a process of demineralisation, caries occurs as a result of acid production by plaque bacteria and has a predilection for sites of plaque accumulation. It has been reported that the two also differ in the nature of the lesion and that they rarely occur simultaneously (Meurman and ten Cate 1996). Authors have suggested that tooth wear and caries affect different subjects and teeth, despite the fact that some drinks and dietary items, which are thought to be a major cause of erosion, are also cariogenic (Michaleck and Mc Ghee 1982, Meurman and ten Cate 1996).

One of the characteristic features of an early carious lesion of enamel is that the lesion is subsurface; that is, most mineral loss occurs beneath an apparently intact surface. This contrasts strongly with Meurman's description of the histological appearance of enamel after a clean tooth surface has been exposed to acid, in which the surface shows etching but there is no subsurface lesion (Meurman and ten Cate 1996). However, Smith and Shaw, in a study of experimentally induced erosion, described a zone of enamel with a translucent appearance reminiscent of the translucent zone seen in early enamel caries, suggesting that the two processes may be less distinct (Smith and Shaw 1987).

In the present study, histological findings in relation to erosion concurred with those of Meurman, in that no translucent zone was apparent in sections demonstrating loss of tooth tissue.

Examination of the two together in the same ground section may also be difficult. In the current study, teeth with extensive caries were excluded because the presence of carious lesions made it difficult to achieve a suitable section at all and may also have modified the appearance of erosion.

Nevertheless, results of the study showed that the two types of tissue destruction may occur together. In the study, a small number of teeth with caries were included in the sample. Numbers were small and no teeth with extensive caries were included. Nevertheless, erosion and caries were seen to affect the same tooth in 10 cases and the same surfaces in six. These findings were confirmed on ground section. It may be hypothesised that in cases where wear and caries apparently affected the same tooth or surface, the wear had been primarily a consequence of attrition. However, in the six cases where both affected the same surface, it was smooth surfaces that had been affected, surfaces where erosion is thought to be a more likely cause.

The study was limited to a small number of teeth. If this finding is a real one, one explanation may be that the two occurrences are distinct and that the finding of both together is a consequence of chance. The teeth were derived from a population with a high prevalence of caries, as shown by the large numbers of teeth that had to be rejected as unsuitable. Previous epidemiological studies may have been confined to populations with a much lower prevalence of one or both conditions, with a commensurately lower probability of both affecting the same child, tooth or surface.

That other studies have failed to see the two together may also relate to the speed of each process, since this factor may be critical to the outcome seen clinically. It has been suggested that caries tends to be slower, with a dynamic equilibrium between phases of de- and re-mineralisation. Erosion is believed to involve more rapid demineralisation with remineralisation occurring only during prolonged periods between intakes of dietary acid (Nunn et al 1996). Whilst this may be true in some populations and individuals, in others carious destruction of the tooth may be very rapid and extensive, effectively masking the presence of erosion occurring at a slower rate in the same tooth. Restorations may also hide the presence of erosive lesions.

Because the study was small and was limited to a selected sample, these inferences must be regarded as conjecture. Confirmation in a larger study is essential before firmer conclusions may be drawn.

5.2 The Survey of kindergarten children in Jeddah

5.2.1 Prevalence of erosion

The aim of the second part of the study was to determine the prevalence of erosion in 2 to 5 years old pre-school children in Jeddah, Saudi Arabia using the index tested earlier. A large sample of children was included, selected to be representative of children in the city of Jeddah who attended kindergartens. Approximately 90% of preschool children in Saudi Arabia are thought to attend either private or publicly funded kindergartens (they were estimated to number approximately 14,000 in 1997-1998). Selection from this sampling frame therefore seemed likely to provide a reasonably representative sample of children of this age in Jeddah. Bias may occur through differences in response. In this study children were selected from both types of kindergarten but agreement to take part was greater amongst families of children at private schools than amongst those of children attending publicly funded kindergartens suggesting some bias was present. However selection was continued in order to provide numbers that were not only large enough for the sample to be reasonably representative of children in the city but also to provide sufficient power to detect differences in oral health and its determinants between schools where these existed.

At clinical examination, 31% of the children had evidence of erosion affecting their maxillary incisors. The most commonly affected teeth were central incisors, 180 (58%) of the children with erosion had one or both central incisor teeth affected. The most commonly affected surfaces were palatal surfaces, 301 (97%) of the children with erosion had at least one palatal surface affected. The estimates made from photographs were similar, with 30% of children who had satisfactory photographs showing erosion with the same pattern of effect in terms of teeth and surfaces affected. The index used allowed assessment of the severity of erosion present. In 186 (60%) cases, erosion was confined to enamel with dentine affected in a much smaller number (119; 39%) and in only 4 cases did erosion extend to affect the pulp.

Previous estimates of prevalence of erosion in primary teeth were discussed in the review of literature, but findings for studies involving primary teeth are summarised again with those of the present study in Table 5.1 for ease of comparison. All of these estimates came from studies in the UK. In all cases previous estimates were derived from clinical examination and although not identical, the index used was in at least three instances similar to that used in the present study with assessment being confined to maxillary incisors and to smooth tooth surfaces.

It is apparent that the estimate of erosion falls within the range seen in the UK, being lower than was reported for 5-6 years old in the National Survey of Child Dental Health, where more than half were affected, and higher than the prevalence of approximately 19% reported for younger children in Great Britain (O' Brien 1994, Hinds & Gregory 1995). The estimate is also little different to that of 29% reported for 3 years old in East Cumbria (Jones and Nunn 1995). Findings were also similar to results of these studies in demonstrating erosion to occur most often on palatal surfaces and for more central than lateral incisors to be affected. Most children in the sample included in the present

investigation who had evidence of erosion had 2 or more teeth affected. Similarly in the study of 1½ to 4½ years old children, more than 2 surfaces per child were affected in the case of both palatal and buccal erosion (Hinds & Gregory 1995).

Prevalence was lower than was reported in the study of 4-5 year old in the West Midlands, where 50% of children had erosion. In the current study, as in the large national studies in the UK, examination was confined to primary maxillary incisor teeth. The higher prevalence seen in the study in the West Midlands may have been partly because all primary teeth were included as well as a different index being used. As well as showing a higher prevalence, overall, more severe erosion may also have affected a higher proportion of children in the West Midlands study. In the current study, 123 of the 309 children with erosion (40%) had erosion extending at least into dentine. This was true of 48% of the 4-5 year old children in the West Midlands sample (Millward et al 1994 a).

A previous study carried out in young adults in Saudi Arabia suggested that prevalence of erosion may be higher than in developed countries, at least in the permanent dentition. In a study of 95 Saudi Arabian male military recruits tooth prevalence was 77% (Johansson et al 1996). This trend for a higher prevalence may be confined to the permanent dentition or may have related to all upper anterior teeth (incisors and canines) being included and to the index used.

In the first part of this investigation, the index was related to wear, irrespective of its likely cause. It has been emphasised in previous studies that differentiation may be difficult. However, for the purposes of the survey, as in previous studies in the UK, measurement of erosion was confined to palatal and labial surfaces and wear affecting

incisal edges was specifically excluded. A high proportion of children are thought to show evidence of attrition in primary teeth, this particularly affected incisal edges. Had these surfaces been included in the present study too, 698 children (71%) could be regarded as having some experience of tooth wear. That 292 out of the 987 of children (30%) had wear affecting incisal edges and wear of labial and/or palatal surfaces indicates that erosion and attrition may occur concurrently in a high proportion of cases. Exact distinctions may be difficult in these cases.

At least three previous studies have suggested that erosion is related to social class (Milosevic et al 1994, Millward et al 1994 a, Jones and Nunn 1995). In two of these erosion was found to be higher amongst those in lower classes and in the third (Millward et al 1994 a) the reverse was true.

Findings in this study gave little indication of any consistent relationship between erosion and social class. Indicators of social class included school type, father's occupation and mother's educational level. In none of these did relationships with erosion reach levels that were statistically significant when analysis was based on single variables. In multi-variate analysis also, social factors failed to emerge as significant predictors of erosion when the effects of other variables were allowed for.

The sample size had been sufficient to allow for comparison between school types. On analysis, a significant difference was found for age groups between the school types with more older children attending private schools. Some trend for variation in erosion with age was apparent. Although not statistically significant it was thought that this difference had potential to confound results but even when based on age adjusted estimates, no significant differences in erosion emerged in relation to school type.

The lack of relationship between indicators of socio economic status and erosion may be a result of at least three factors. First, the lack of relationship may be a real one and the effect of social factors on diet for example, may not be great enough to influence erosion. Findings of a relationship in past studies may therefore have been chance results or a result of sampling variation. This may be borne out by the fact that no relationship was demonstrated in at least one previous large study which included both erosion and social class (Hinds & Gregory 1995). Secondly the absence may have been related to the methods of social class assessment employed. That school type was an imperfect measure may be shown by the fact that a higher proportion of children at public schools had mothers who had been educated to college level or beyond. More conventional measures of socio-economic status such as based on father's occupation for example, are complex, often including more than one component. In Saudi Arabia, they may also be made more difficult to use by the pace of modernisation and social change affecting the country. As a result of these changes the income of many people has increased greatly within a short time interval and their life styles and value systems may well have altered radically in consequence. Nevertheless, the method used was one that has been employed previously. That the measures were appropriate may also be indicated by the fact that caries and rampant caries were found to relate to social variables measured both in single variate and in multivariate analyses.

Thirdly, it may be that those habits and practices which influence erosion relate differently to social factors in Saudi Arabia than in other countries. It is of note that not all previous investigations have demonstrated a relationship between erosion and social factors and results have sometimes been contradictory. Even if a relationship does exist it may not be sufficiently strong to appear consistently in all studies.

It may therefore be concluded that the prevalence of erosion in primary teeth in young children in Jeddah is probably similar to that seen in the UK when measured in a similar way. As have some previous studies, the investigation failed to provide evidence of a social class relationship with erosion.

5.2.2 Prevalence of caries and rampant caries

In the study 73 % of the children were found to have caries and 34 % to have rampant caries. On average, children had 4.8 teeth and 12.7 surfaces per child affected by caries. The high prevalence and dmft values reported here appear to be similar to estimates derived from previous studies for children in the city. Prevalence values reported for 6 year old children in Jeddah have been in the region of 70-76% and dmft values have ranged from 4.6 to 5.5 (Al-Kateeb et al 1991, Al-Amoudi et al 1996).

That these children were at the time of continuing caries activity may be demonstrated by the significant increase in dmft and dmfs with age, with treatment in terms of missing and filled surfaces contributing little to the changes.

In considering findings of the survey it must be borne in mind that results, for both erosion and caries, relate to young children living in one coastal city in Saudi Arabia. It cannot be assumed that the estimates necessarily represent prevalence elsewhere in the kingdom. Nevertheless simple comparisons suggest that the values seen are also comparable to more recent estimates for young children in other parts of Saudi Arabia. Prevalence of caries for children aged 6 or less in Saudi Arabia has ranged from 45% to 89 % in studies reported since 1990 (Al-Shammary et al 1990, Al-Kateeb et al 1991, Al Amoudi et al 1996, Wyne et al 1996, Al-Mohammedi et al 1997, Al-Tamimi & Peterson 1998, Tahir & Maktabi 1997) and dmft values from 0.2 amongst a group of 2 year old

boys in the city of Riyadh (Al-Mohammedi et al 1997) to 7.12 in a sample of 5 years old in Al Kharj (Tahir & Maktabi 1997). Not all studies have included assessment of rampant caries or have used the definition employed in the current study. Nevertheless the prevalence of 34% for rampant caries was within the range of 15-43% reported for a group of 0-6 year olds in Riyadh (Wyne et al 1995).

Caries has been shown clearly to relate to social class with, in westernised developed countries, levels of disease being higher amongst children in the lowest classes and those whose families were especially disadvantaged (Hinds & Gregory 1995, Todd 1975, Todd & Dodd 1985, O'Brien 1994). The trend for caries to be higher in children from lower social classes has also been seen in young children in at least one study in Saudi Arabia. In the study of 4-6 years old boys in Riyadh, prevalence of caries was higher, at 72%, in children from lower social classes and lower at 54%, in those from higher social classes (Al Mohammadi et al 1997). This study showed the same relationship with children from families in the highest classes having the lowest levels of disease and those in the lowest classes having the highest. Both school type and mothers' education were also clearly related to caries. In this study as in a previous one carried out in Jeddah caries was more prevalent and dmft and dmfs were higher in children from publicly funded schools (Al-Kateeb et al 1991). Caries was also more prevalent in children whose mothers were less well educated. Both school type and mother's education were significantly related to caries and to rampant caries in both multivariate and single variate analysis. Although differences were significant in single variate analysis, findings were less consistent in relation to father's occupation. There appeared to be only small differences in caries prevalence between those whose fathers were classified as professional (but not higher professional), those classified as middle

class and the lowest classes, perhaps reflecting difficulties in assessing social class effectively in Saudi Arabian society at the present time.

It may be concluded that caries prevalence and severity appear to be similar to those seen in Jeddah and elsewhere in Saudi Arabia in recent years and demonstrate the continuing high prevalence of the disease in younger children.

The relationship to social class is similar to that seen in developed countries such as the UK in demonstrating the worst oral health in children from the lowest social classes.

5.2.3 Caries and Erosion

The results of the first part of this study carried out using exfoliated and extracted teeth illustrated that erosion and caries could affect the same tooth or tooth surface. This was confirmed in the survey, where, in contrast to previous reports, results provided evidence of a positive relationship between erosion and caries. This relationship was particularly marked when children with rampant caries were excluded from analysis, when it was seen as significant not only in single variate analysis but also was one of only four to emerge as having an independent relationship to the outcome of erosion in multi-variate analysis. With a higher caries prevalence it is to be expected that erosion and caries would occur together more often but confidence intervals about the Odds Ratio suggested that children with caries (excluding rampant caries) had up to twice the risk of having erosion compared with those who were clinically caries free. Twenty nine per cent of children with rampant caries did show erosion but the relationship between the two was less clear. This contradictory finding may have been at least partly a consequence of the difficulty which lay in measuring both forms of tooth tissue loss in the same surfaces of primary incisor teeth.

The lesions of rampant caries and erosion are very dissimilar, erosion resulting in smooth shiny and shallow defects and rampant caries in more localised, rough, destructive and deeper lesions. It therefore seems unlikely that there was confusion between the two. In permanent teeth and in westernised countries caries may often be a slower process than erosion but this may not be true in primary teeth in a population with higher caries levels. As suggested in the first part of this study it may be that in at least some cases, superimposition of the greater and more rapid destruction of caries had effectively masked or removed any evidence of erosion or that erosion itself may promote the mechanisms of rampant caries. further research would be of value in understanding more exactly the relationship between the two processes.

5.2.4 Use of photographs

Previous studies of erosion in children have been based on clinical examination. In the present study, assessment was also made through photographs. Photography has been thought to offer particular advantages in other types of investigation. In studies of enamel defects for example, photographs make randomisation easier and allow for repeated assessment without the need to re-examine the subject. Photographs are easily transported and could also facilitate national and international comparisons using standardised measurements by one or several examiners. In the current study, results in the first part of the investigation suggested a good level of agreement between clinical and photographic assessment of erosion in exfoliated and extracted teeth. Results in the survey showed that the method was feasible and that it was acceptable to a large proportion of the young children included; it proved possible to take both labial and palatal views of a very high proportion (87%) of the young children who took part.

Findings also showed a degree of comparability. In direct comparisons of scores at tooth surfaces level for example, agreement was seen in 93% of surfaces. Estimates of prevalence showed a difference of only 6 percentage points. Where differences did occur, these appeared to lie especially in distinguishing erosion involving dentine from that confined to enamel and to relate to cases where both lateral and central incisors were affected. Although the proportions with only central incisors were affected appeared similar, fewer cases were diagnosed using photographs in which both central and lateral incisors showed evidence of erosion. This may have related at least partly to judging severity in teeth adjacent to each other in the same mouth. In a higher proportion of instances where disagreement did occur, photographic scores were lower than those made clinically suggesting that scores from photographs tended to underestimate the extent of tooth tissue loss. If the erosion in central incisors was more severe, and judgement of this level was altered in the case of photographs, then this may have reduced the likelihood of diagnosing erosion in lateral incisors in the same child. It could be seen that lateral incisors were very seldom scored as 1 or more in the absence of similar or higher scores in the adjacent central incisors. In addition, in 48 out of 60 cases where scores for central incisors were lower on photographs than clinically, all scores for the adjacent laterals were reduced to zero and in a further 5 it was reduced from a maximum of 2 to 1.

The amount of agreement seen and the extent to which photographs proved feasible would seem to confirm that photographs do have some potential to be of value in developing national and international comparisons in measuring erosion. However, there was evidence of some disagreement and the method may well benefit from refinement. More sophisticated imaging techniques, such as through the use of digital

cameras, and use of computer enhancement methods may merit further investigation towards this end.

5.3 The Questionnaire

The survey provided evidence of the prevalence of erosion and caries in the group of kindergarten children. The method also included a questionnaire to be completed by parents, aimed at investigating possible aetiological factors related to erosion in this group of children. The form included questions about a number of dietary items reported in the past to be related to erosion.

It has been suggested that caries and erosion may have common dietary causes. Thus, drinks with low pH and high content of non-milk extrinsic sugars may carry both erosive and cariogenic potential (Imfeld 1983).

Information drawn from the questionnaire was therefore related not only to erosion but also to caries in order to try and establish common and separate determinants of disease in the group of Saudi Arabian children.

Two drawbacks of questionnaire studies are first that they often suffer from bias as a consequence of non response and secondly, that they indicate only reported behaviour. The current investigation was no exception in these respects. The fact that response was higher for children in private schools gives indication of likely bias. It was clear from the form that the survey was related to oral health and more dentally motivated parents would seem more likely to take part. The form was sent home to parents through the school and it is also likely that more literate parents would find it easier to respond. Mothers of only eleven children who took part in the study had education that was limited to primary school level or less. Despite the evidence therefore of some degree of

bias in response, the survey and questionnaire study did include children from a spectrum of social classes.

All questionnaires indicate reported rather than actual behaviour but alternative methods of investigating diet, such as using diet diaries or 24 hour recall interviews are complex and have drawbacks. They would for example have required greater degrees of co-operation and motivation on the part of parents and the schools as well as more specialist investigators and may therefore have been less feasible methods for the young kindergarten children in this sample. It is of note that, despite their disadvantages, questionnaires to be completed by parents at home have been widely used in previous studies of large samples (O'Brien 1994). Where it was relevant, questions from previous studies were included in the present one. Previous investigations of erosion have been limited to English speaking countries, and questions were therefore translated and also modified slightly where necessary in order to make them culturally more appropriate for children in Saudi Arabia.

Analysis included simple comparisons relating individual factors to the outcomes of erosion and caries but determinants of either are unlikely to have wholly independent effects. The sample size in the study was sufficient for multi-variate as well as single variate analysis. This allowed for assessment of the independent effect of each factor when others were allowed for. The method has been used previously in the survey of 1½- 4½ year old children in the UK (Hinds & Gregory 1995) and aids in identification of major factors with independent effects amongst a large number of variables.

Using this method, and with all variables included only 3 factors emerged as significant in relation to erosion. These were use of Vitamin C supplements, frequency of use of carbonated drinks at the time of the study and the consumption of fruit syrup from a

feeding bottle at bed/nap time when the child was a baby. Although this appears to be in contrast to findings in the survey of 1½ to 4½ year olds in the UK where no significant relationship was seen between erosion and dietary behaviour, closer examination of data in this past study provides some evidence of trends. For example, of the 3½ to 4½ year olds who drank carbonated drinks most days 22% had erosion, compared to only 8% amongst children who had this type of drink less often (Hinds & Gregory 1995).

In the current study use of Vitamin C supplements showed a clear relation to erosion. Confidence intervals about the odds ratio suggest that children who were given Vitamin C supplements may be at up to 4.7 times the risk of having erosion compared to those who did not do so. Use of Vitamin C also emerged as significant in relation to rampant caries in this group of children, where it also appeared to present a potentially high degree of risk. It has already been suggested that measuring erosion and rampant caries in the same tooth surfaces may have been difficult. If the association between Vitamin C and both erosion and rampant caries are real it might perhaps be speculated that the effects of ascorbic acid may not only be on enamel directly but also by indirectly potentiating or contributing to the process of rampant caries in the same tooth surfaces in susceptible children. However, the number of children who were given Vitamin C supplements was relatively small (only 54 children) so that caution is needed in considering these apparent associations.

The review of literature showed that the role of carbonated drinks in the aetiology of erosion has been highlighted in many previous studies. The relationship was also seen clearly in this investigation in relation to the frequency with which drinks were given at the time of the study. Thirty seven per cent of the 397 children who were reported to have carbonated drinks once or twice a day or more often had erosion compared to 28%

of the 496 who had them less often. Confidence intervals about the odds ratio in multivariate analysis suggested that children who had these drinks at least daily may be at up to 1.9 times the risk of having erosion. As in the case of Vitamin C supplements, results of multivariate analysis showed frequency of giving carbonated drinks to be a risk factor that was common to both erosion and rampant caries, the frequency of carbonated drinks representing a risk of up to 2.3 times for the latter. As well as having low pH, carbonated drinks are most often high in non-milk extrinsic sugars. Frequency of intake of these drinks may therefore be thought likely to relate to caries. This may also be suggested by the statistically significant relationship seen in single variate analysis between caries and frequency of carbonated drinks but this pattern did not emerge in the more complex multi-variate analysis when caries as a whole was used as the outcome. This may reflect the interactions that occur between the factors included, effectively masking or reducing the influence of any one variable in the sample of children or may be a consequence of using a relatively crude measure of frequency of intake as an indicator of pattern of consumption.

Drinks given at night or at naptime may carry particular erosive potential as the protective mechanisms of saliva may be reduced during sleep. In this study, multi-variate analysis showed consumption of diluted fruit syrup drinks as a baby from a feeding bottle at bedtime to be related to erosion. Numbers given a drink of this type were small, only 56 children were reported to have been given diluted fruit syrups in an infant feeding bottle when they were babies and only 35 had been given these at night, making firm conclusions on this basis alone very difficult but other relationships were seen which were consistent with this finding. That diluted fruit syrup drinks may be

important in erosion was also seen in single variate analysis where use at bed time and frequency of use at the time of the study were both significantly related to erosion.

As well as being important in erosion diluted fruit syrup drinks also emerged as important in relation to caries, where both use of these drinks in a bottle when the child was a baby and frequency of use at the time of the survey emerged as significant in multi-variate analysis. Diluted fruit syrups given when the child was a baby was amongst the highest risk factors for caries and may have represented up to 9 times the risk for caries in the population from which the children were drawn. As in the case of erosion, firm conclusions are difficult because of the small numbers but fruit syrups given at bed time at the time of the survey (which were more common; 65 children) were also related to caries in single variate analysis, perhaps providing a further indication of their role in caries aetiology.

It may be thought therefore that results of the questionnaire provided some evidence to support the role of dietary factors that are common to both caries and erosion in young children. Not all of the relationships seen were wholly consistent.

Although evidence about diluted fruit syrups appeared to show some consistency in relation to both erosion and caries, their was little clear evidence to link this type of drink to rampant caries in the sample of children. This was unexpected. In the UK, drinks given in feeding bottles, particularly at night or naptime, have been particularly associated with the disease (Holt 1982). It may be that in the sample of children from Jeddah, other aetiological agents have assumed greater importance in the aetiology of rampant caries effectively masking the effect of syrups and of other types of drink.

Dummies dipped in sweet substances such as syrups or honey have been shown to be important in the past (Winter 1996) but are now rarely used in the UK. In this study, dummies dipped in syrup, sugar or other sweet agent had been given to 215 of the 987 children (22%) and their use proved to be the strongest determinant of disease to emerge for both caries and rampant caries.

Some factors strongly associated with erosion in the past failed to be apparent here. Relatively few of the foods and the fruits reported as being related to erosion in the past appeared to relate to erosion in the children included. The effect of dietary factors will relate not only to its effect on tooth tissue but also on how often it is eaten or drunk. Thus, for example, frequency of eating grapefruits, which have been identified as erosive in several in vitro studies in the past, was not clearly identifiable as important but this may be partly because very few of the children (only 22) had grapefruits once a day or more often.

Prevalence of erosion also appeared to be unrelated to the method of drinking used. This may have been partly a consequence of the fact that only incisor teeth were assessed. In most cases, palatal rather than labial surfaces were affected. Examination of all primary teeth may have shown a difference in pattern. It may also be that the relatively young children were not especially consistent in the method of drinking used.

Overzealous oral hygiene has been suggested as promoting the effects of erosion. Three aspects of oral hygiene habits were considered in the questionnaire: age at starting to brush, frequency of brushing and whether or not the child was given help in brushing. None of the three proved to be related to prevalence of erosion in the sample of children but two of three proved to be related to caries. In multi-variate analysis, children for whom toothbrushing began after one year of age proved to be at significantly higher risk

of both caries and rampant caries and children who had no help in brushing were also at higher risk of caries. Frequency of brushing did not appear to be as important. This contrasts with findings in the study of 1½-4½ year olds in the UK for example, where children brushing at least twice a day were less likely to have caries (Hinds & Gregory 1995).

Fluoride toothpastes used in toothbrushing are of major importance in caries prevention (Murray et al 1991). Fluoride has also been suggested as having potential to increase resistance to erosion (Teo et al 1997). Most toothpastes in Saudi Arabia do contain fluoride and in the current investigation a question was asked about type of toothpaste used. However, a high proportion of families failed to indicate a type and answers were not considered sufficient for analysis. More exact information may well have been of value but might have been difficult to collect within the constraints of the method used here.

As well as those common to both erosion and caries, other relationships of potential importance seen with the outcomes of caries and/or rampant caries included feeding method used in infancy, fruit juices given at night and frequency of eating dates.

Feeding method has been associated with caries in the past. However, the relationship seen here was the reverse of that seen elsewhere. Thus the children who were wholly breast fed had more rampant caries (and caries at all) than did those who had been wholly or partly bottle fed. Rampant caries was also more common in children breast fed beyond the age of one year. The apparent relationships need care in interpretation because of the confounding effect of social class. In countries where caries is less common in children who are breast fed, this type of infant feeding is more common in higher social classes. In the present study breast feeding (and more prolonged breast

feeding) was more common for children in lower social classes. Such children may not only have been breast fed but may also have been more likely to have been given sweetened dummies and less likely to have had their teeth brushed at an early age for example.

Fruit juices were given at bedtime to 144 of the children and dates were eaten at least once a day by 426 of the group. The former was seen as a risk factor for caries, but not for rampant caries in multi-variate analysis and the latter was seen to relate to both caries and rampant caries in single variate analysis. Fruit juices contain high levels of non-milk extrinsic sugars but there has been little clear evidence of their relationship to caries in past studies and this finding may be simply a chance result. The same is true of dates; no previous clinical studies have investigated the relation between dates and caries, however it was reported that dates contain about 80% carbohydrates, most of which are sugars that are readily fermented by the oral flora, fructose, glucose and sucrose. Their acidogenic potential was found to be similar to glucose and sucrose in at least one in vitro study (Salako & Al Bagieh 1994).

The importance of dietary factors in caries in children in Saudi Arabia has been stressed in the past (Wyne et al 1995, Wyne & Khan 1995). Findings here would lend emphasis to this concept, particularly with respect to drinks.

It may be concluded that the questionnaire study provided evidence of associations that may be important in the aetiology of erosion. The factors identified may also have been amongst dietary contributors to caries and/or rampant in this group of children.

Table 5.1 **Summary of prevalence studies of erosion in children**

Author &year	Country	Age gp	Sample size	Prevalence
Jones & Nunn 1995	EastCumbria	3	135	28.9% had one or more maxillary incisors affected. 17% with both enamel & dentine involvement. (all dental erosion was on the palatal with only 2 cases on the buccal surface).
O'Brien 1994	UK	5-6	17061	52% with erosion on their primary incisors. 24% with dentine involvement.
Hinds & Gregory 1995	UK	1½-4½	1496-1522	19% with erosion on the palatal surfaces (8%with dentine involvement). 10% with erosion on the buccal surfaces (2%with dentine involvement).
Millward et al 1994	West Midland	4 -5	178	50% of the children had erosion (most commonly on the palatal surfaces of maxillary incisors, over 30% with dentine involvement).
Millward et al 1994	Birmingham	4 -16½	101	80% of max incisors had evidence of tooth wear, mostly on the palatal surface. 30% primary molars with dentine exposed.
Present study 1998	Jeddah (Saudi Arabia)	2-5	987	31% of children had erosion affecting their max incisors. 12.5 with dentine involvement.

*

CHAPTER SIX

PRINCIPAL FINDINGS

6.1 Review of Literature

From the review of literature it was found that:

1. Dental erosion has been the subject of case reports over more than 50 years and of increasing numbers of in vitro and in vivo studies. Many have been concerned with identifying aetiological factors, particularly dietary acids.
2. Erosion may affect either dentition but has proved difficult to measure, particularly epidemiologically. One reason for this has been the difficulty in differentiating erosion from attrition and abrasion. Some indices make no attempt at distinction but others confine measurement to particular tooth surfaces.
3. There have been several methods introduced to measure erosion under experimental conditions in vitro. These may not relate to the more complex situation in vivo.
4. The prevalence of erosion in primary teeth in children in the UK is thought to be high, with approximately 50% of 5 year olds affected. Some studies have suggested that erosion is seen more often in children from higher social classes but findings are not consistent.
5. In the UK, erosion has been suggested more often to affect children who are less susceptible to caries.

6.2 Validity of Index

From the study of 41 exfoliated and extracted primary anterior teeth it was found that:

1. On visual inspection 31 of the teeth showed evidence of wear. In 27 cases wear affected incisal edges and in 19 palatal surfaces. None of the labial surfaces were

affected. Wear was confined to enamel in the case of 14 teeth, in 17 it extended into dentine and no case did it involve the pulp.

2. Assessment of photographs of the teeth gave scores that were the same as those for visual examination in the case of all 41 teeth.
3. Comparison of findings when the teeth were sectioned and examined microscopically showed that scores given on visual and photographic assessment gave a slightly lower prevalence of wear (33 teeth showed wear on sectioning) and underestimated its severity; in the case of 11 out of the 14 teeth where wear had been thought to be confined to enamel, this was found to extend into dentine on section. Sensitivity of the index was 0.94, and specificity was 1.0.
4. Repeated visual examinations gave a kappa value of 0.96, and repeat reading of photographs gave one of 0.77. The equivalent value for repeat reading of sections was 0.89.

6.3 The Survey

From the survey of 987 children it was found that:

1. Three hundred and nine (31%) of the children showed erosion of their primary maxillary incisors on clinical examination. One hundred and eighty six (19%) had erosion confined to enamel but for 123 (12%) it has extended to involve dentine and/or pulp. Erosion had affected central incisors in 180 children, lateral incisors in 6 and both tooth types in 123. Three hundred and one (97%) children had palatal erosion, 1 had labial surfaces affected and 7 had erosion of both surface types.
2. Readable photographs were available for 727 of the sample of children. Of these, 220 (30%) had erosion present on photographs and 264 (36%) had erosion scored

clinically. Agreement between photographic and clinical scores was seen in 93 % of surfaces.

3. At clinical examination, 720 of the 987 children had caries (73%) and 336 (34%) had rampant caries. Mean dmft was 4.80 (± 4.87) per child and mean dmfs was 12.67 (± 15.46) per child.
4. Erosion was positively related to caries in the sample of children included. Of the 384 children with caries but not rampant caries, 141 (37%) had erosion, a significantly higher proportion than the 72 (27%) out of 267 who were clinically caries free. The null hypothesis of there being no relationship between erosion and caries in this group of children could therefore be rejected.
5. Estimates of the prevalence of erosion were similar to those seen in the UK using a similar index and in children of equivalent age.
6. The prevalence of caries and rampant caries were similar to findings in studies in Saudi Arabia in the last 10 years.

6.4 The Questionnaire to parents

Through analysis of findings in relation to answers given in the questionnaire completed by parents it was found that in relation to erosion:

1. There was no clear relationship between erosion and social class. 211(21%) of children whose fathers were in occupations classified as higher professions had erosion, as did 190 (19%) of those from the lowest social classes. The null hypothesis was therefore not rejected.
2. Multi-variate analysis showed Vitamin C supplements (OR = 2.6), the consumption of fruit syrup drinks as a baby from a feeding bottle at bed/nap time (OR = 2.3), and frequent use of carbonated drinks at the time of the study (OR = 1.4) to be

significantly related to erosion. The null hypothesis of no relationship between dietary factors and erosion could therefore be rejected.

3. All of the dietary items related to erosion also showed some relationship to caries and/or rampant caries.
4. Significant relationships were also seen between erosion and diluted fruit syrup drinks when these were given in feeding bottles when the child was a baby, when they were given at night and when they were given more frequently, but these were lost when other factors were allowed for.
5. No significant relationship was seen between oral hygiene practices and erosion and the null hypothesis was therefore not rejected.

In relation to caries:

1. Caries and rampant caries were related to age of the child and to social class. More disease was seen in older children and in children from lower classes, those from publicly funded schools and those whose mothers had received less education.
2. In multi-variate analysis both caries and rampant caries were related to use of sweetened dummies. Two hundred and fifteen children had used these, 190 (88%) of whom had caries and 125 (58%) had rampant caries (OR = 3.2 for caries, OR = 4.3 for rampant caries).
3. Caries was also related to fruit syrups (OR= 2.1, 3.1), and rampant caries to use of Vitamin C supplements (OR = 2.3) and to carbonated drinks (OR =1.7).
4. Oral hygiene practices were significantly related to caries and to rampant caries, with the time at which brushing started being important for both diseases (OR = 1.8 for caries, OR = 1.6 for rampant caries).

ACKNOWLEDGEMENTS

Thanks to God who made this possible and supported me through it all.

I dedicate my work to my dearest husband (Hatim), for his patience, his love, his kindness and his support without whom this would not have been possible.

To all my family especially my father (Ibrahim), my mother (Badia), who have always been there for me.

I would like to extend my deepest appreciation to Dr Ruth Holt who guided and supervised me at every step of this research and for her encouragement during this research. Her supervision has been excellent, and I appreciate greatly the time and effort she put into this project.

I also wish to thank Professor Raman Bedi for his advice and support through out, and other members of the staff in the Transcultural oral health department of the Eastman Dental Hospital.

I am also very grateful to Professor Paul Speight for his guidance in the histological part of the study.

I would like to thank the Ministry of Defence and Aviation for their scholarship, the Ministry of Higher Education for the permission for the study, the schools, the children and their parents for their co-operation.

My friend and colleague Dr Rawda Ayoub for her help in collecting the teeth for the study and for her support in Jeddah when I was away from the hospital, to my friends Maha Al Sarheed and Manal Jamjoom for their friendship and support.

REFERENCES

Abrams RA and Ruff LC. Oral signs and symptoms in the diagnosis of bulimia. Journal of American Dental Association 1986; **113**: 761-764.

Addy M, Absi EG, and Adams D. Dentine hypersensitivity. The effects in vitro of acids and dietary substances on root-planed and burred dentine. Journal Clinical Periodontology 1987; **14**: 274-279.

Adenubi J. Rampant caries in Nigerian children: preliminary report. Journal of International Association of Dentistry for Children 1982; **13**: 31-37.

Aine L, Baer M, and Maki M. Dental erosions caused by gastroesophageal reflux disease in children. Journal of Dentistry for Children 1993; **60**: 210-214.

Al-Amoudi N, Salako NO and Massoud I. Caries experience of children aged 6-9 years in Jeddah, Saudi Arabia. International Journal of Paediatric Dentistry 1996; **6**:101-105.

Al-Ghanim N. Caries risk assessment by a cross-sectional discrimination model in a preschool Saudi population in Riyadh. MSc thesis 1996. King Saud University.

Al-Kateeb TL, Al-Marsafi Al, O'Mullane DM. Caries prevalence and treatment need amongst children in an Arabian community. Community Dentistry and Oral Epidemiology 1991; **19**:277-80.

Allan DN. Dental erosion with lemon juice. British Dental Journal 1967; **122**: 300-302.

Allen RJL. The estimation of phosphorus. Biochemistry Journal 1940; **24**: 858-865.

Al-Mohammadi SM. An investigation into factors related to developmental defects of enamel in Saudi children. PhD Thesis 1995. University of Newcastle.

Al-Mohammadi SM, Rugg-Gunn AJ, and Butler TJ. Caries prevalence in boys aged 2, 4, and 6 years according to socio-economic status in Riyadh, Saudi Arabia. Community Dentistry and Oral Epidemiology 1997; **25**: 184-186.

Al-Shammary A, Guil E and El-Buckly M. Prevalence of caries in primary school children in Saudi Arabia. Community Dentistry and Oral Epidemiology 1990; **18:** 320-321.

Al-Shammary A, Guil E, El-Buckly M and Lamborne A. An oral health survey of Saudi Arabia: phase 1 (Riyadh) 1991. King Saud University.

Al-Shammary A, Guil E, El-Buckly M and Sulaimani S. Oral Health survey in Saudi Arabia 1991-1994. Final report 1994. King Saud University.

Al-Tamimi S and Petersen P. Oral health situation of schoolchildren, mothers and schoolteachers in Saudi Arabia. International Dental Journal 1998; **48:** 180-186.

Andon MB, Kanerva RL, Rotruck JT and Smith KT. Method of preventing tooth enamel erosion utilizing an acidic beverage containing calcium. US Patent 1992; **5** (108): 761.

Andrews FF. Dental erosion due to anorexia nervosa with bulimia. British Dental Journal 1982; **152:** 89-90.

Asher C and Read MJF. Early enamel erosion in children associated with the excessive consumption of citric acid. British Dental Journal 1987; **162**: 384-387.

Bartlett DW, Blunt L and Smith BGN. Measurement of tooth wear in patients with palatal erosion. British Dental Journal 1997; **182**: 179-184.

Bartlett DW, Coward PY, Nikkah C and Wilson RF. The prevalence of tooth wear in a cluster sample of adolescent schoolchildren and its relationship with potential explanatory factors. British Dental Journal 1998; **184:** 125-129.

Bartlett DW and Smith BGN. The dental impact of eating disorders. Dental Update 1994; **21**: 404-407.

Beal JF. Social factors and preventive dentistry. In: Preventive of oral disease. Oxford: University Press (3rd Edition) 1996; 217-233.

Bishop K. Wear now? An update on the etiology of tooth wear. Quintessence International 1997; **28:** 305- 313.

Centerwall BS, Armstrong CW, Funkhouser GS and Elzay RP. Erosion of dental enamel among competitive swimmers at a gas-chlorinated swimming pool. American Journal Epidemiology 1986; **123**: 641-647.

Dahl BL, Oilo G, Andersen A, and Bruaset O. The suitability of a new index for the evaluation of dental wear. Acta Odontologica Scandinavica 1989; **47:** 205-210.

Davis WB and Winter PJ. The effect of abrasion on enamel and dentine after exposure to dietary acids. British Dental Journal 1980; **148**: 253-256.

Donachie MA and Walls AWG. The tooth wear index: a flawed epidemiological tool in an ageing population group. Community Dentistry and Oral Epidemiology 1996; **24**: 152-158.

Duggal MS and Curzon MEJ. An evaluation of the cariogenic potential of baby and infant fruit drinks. British Dental Journal 1989; **166**: 327-330.

Eccles JD. Dental erosion of non-industrial origin. A clinical survey and classification. Journal of Prosthetic Dentistry 1979; **42**: 649-653.

Eccles JD. Erosion affecting the palatal surfaces of upper anterior teeth in young people. British Dental Journal 1982; **152:**375-378.

Eccles JD and Jenkins WG. Dental erosion and diet. Journal of Dentistry 1974; **2**: 153-159.

Elliott JC, Anderson P, Gao XJ, Wong FSL, Davis GR and Dowker SEP. Application of scanning microradiography and x-ray microtomography to studies of bones and teeth. Journal of X-ray Science and Technology 1994; **4**:102-117.

Feagin F, Koulourides T and Pigman W. The characterization of enamel surface demineralisation, remineralisation and associated hardness changes in human bovine material. Archives of Oral Biology 1969; **14:**1407-1417.

Fuller JL and Johnson WW. Citric acid consumption and the human dentition. Journal of American Dental Association 1977; **95:** 80-88.

Gedalia I, Dekuar A, Shapira L, Lewinstein I, Goultschin J, and Rahamim E. Enamel softening with Coca-Cola and rehardening with milk or saliva. American Journal of Dentistry 1991a; **4**:120-122.

Gedalia I, Galon H, Rennert A, Bidereo I and Mohr I. Effect of fluoridated citrus beverage on dental caries and on fluoride concentration in the surface enamel of children's teeth. Caries Research 1981; **15:**103-108.

Gedalia I, Ionat-Bendat D, Ben-Mosheh S and Shapira L. Tooth enamel softening with a cola type drink and rehardening with hard cheese or stimulated saliva in situ. Journal of Oral Rehabilitation 1991b; **18**: 501-506.

Giunta JL. Dental erosion resulting from chewable vitamin C tablets. Journal of American Dental Association 1983; **107**: 253-256.

Grando LJ, Tames DR, Cardoso AC and Gabilan NH. In vitro study of enamel erosion caused by soft drinks and lemon juice in decidous teeth analysed by stereomicroscopy and scanning electron microscopy. Caries Research 1996; **30**: 373-378.

Gregory JR, Collins DL, Davis PSW, Hughes JM and Clarke PC. National Diet and Nutrition Survey: children aged 1½ to 4½ years. Volume 1: Report of the diet and nutrition survey, HMSO1995, London.

Grenby TH. Methods of assessing erosion and erosive potential. Europe Journal of Oral Science 1996; **104**: 207-214.

Grenby TH, Mistry M and Desai T. Potential dental effects of infants fruit drinks studied in vitro. British Journal of Nutrition 1990; **64:** 273-283.

Grobler SR, Senekal PJC and Kotze T. The degree of enamel erosion by five different kinds of fruit. Clinical Preventive Dentistry 1989; **11:** 23-28.

Grobler SR, Toit IJ, and Basson NJ. The effect of honey on human tooth enamel in vitro observed by electron microscopy and microhardness measurements. Archives of Oral Biology 1994; **39**: 147-153.

Guile E and Al-Shammary A. Saudi Arabian Dentistry: A factual and conceptual view. Journal of Public Health Dentistry 1987; **47:** 16-18.

Harrison JL and Roder LB. Dental erosion caused by cola beverages. General Dentistry 1991; **39**: 23-24.

Hartles RL and Wagg BJ. Erosive affect of drinking fluids on the molar teeth of the rat. Archives of Oral Biology 1962; **7:** 307-315.

Hellstrom I. Oral complications in anorexia nervosa. Scandinavian Journal of Dental Research 1977; **85**: 71-86.

High AS. An unusual pattern of dental erosion. A case report. British Dental Journal 1977; **143**: 403-404.

Hinds K and Gregory JR. National Diet and Nutrition survey: children aged 1½ to 4½ years. Volume 2: Report of the dental survey. Office of Population Censuses and Surveys, HMSO 1995, London.

Holloway PJ, Mellanby M and Stewart RJC. Fruit drinks and tooth erosion. British Dental Journal 1958; **104**: 305-309.

Holt RD, Joels D and Winter GB. Caries in preschool children. British Dental Journal 1982; **153**:107-109.

Holt RD, Winter GB, Downer MC, Winter GB, Hay I and Bellis W. Fourth study of caries in preschool children in Camden. British Dental Journal 1996; **181**: 405-410.

Hugoson A, Bergendal T, Ekfeldt A, and Helkino M. Prevalence and severity of incisal and occlusal tooth wear in an adult Swedish population. Acta Odontologica Scandinavica 1988; **46:** 255-265.

Imfeld T. Acidogenic and erosive potential of soft drinks and mineral waters. In: Monographs in Oral Science. Identification of low caries risk dietary components, Basil, Switzerland: Karger 1983; **11:** 165-74.

Imfeld T. Prevention of progression of dental erosion by professional and individual prophylactic measures. European Journal of Oral Science 1996; **104:**215-220.

James PMC and Parfitt GJ. Local effects of certain medicaments on the teeth. British Medical Journal 1953; **2**: 1252-1253.

Jarvinen VK, Rytomaa II and Heinonen OP. Risk factors in dental erosion. Journal of Dental Research 1991; **70**: 942-947.

Johansson A, Johansson A, Birkhed D, Omar R, Baghdadi S and Carlsson G. Dental erosion, soft drink intake, and oral health in young Saudi men and the development of a system for assessing erosive anterior tooth wear. Acta Odontologica Scandinavica 1996; **54:** 369-378.

Johnson GK and Sivers JE. Attrition, Abrasion and Erosion: Diagnosis and Therapy. Clinical Preventive Dentistry 1987; **9**: 12-16.

Jones SG and Nunn JH. The dental health of 3-year-old children in East Cumbria 1993. Community Dental Health 1995; **12,** 161-166.

Kilpatrick NM and Welbury RR. Advanced Restorative Dentistry. In: Paediatric Dentistry Ed: Welbury RR, Oxford University Press. 1997; **9:** 173-197.

Koulourides T and Chien MC. The ICT in situ experimental model in dental research. Journal Dental Research 1992; **71:** 822-827.

Koulourides T. Remineralization of enamel as a defense against caries. In: Chemistry and physiology of enamel. Ann Arbor, University of Michigan Press. 1971: 109-119

Larsen MJ. Dissolution of enamel. Scandinavian Journal of Dental Research 1973; **81:** 518-22.

Larsen MJ. Chemical events during tooth dissolution. Journal of Dental Research 1990; **69:** 575-580.

Lewis KJ and Smith BGN. The relationship of erosion and attrition in excessive tooth tissue loss. British Dental Journal 1973; **135**: 400-404.

Linkosalo E and Markkanen H. Dental erosion in relation to lactovegetarian diet. Scandinavian Journal of Dental Research 1985; **93**: 436-441.

Lussi A, Jaggi T and Scharer S. The influence of different factors on in vitro enamel erosion. Caries Research 1993; **27**: 387-393.

Lussi A, Schaffner M, Hotz P and Suter P. Dental erosion in a population of Swiss adults. Community of Dentistry and Oral Epidemiology 1991; **19**: 286-290.

Mackie IC and Blinkhorn AS. Unexplained losses of enamel on upper incisor teeth. Dental Update 1989; **16:** 403-404.

Mackie IC and Hobson P. Case reports: Dental erosion associated with unusual drinking habits in childhood. Journal of Paediatric Dentistry 1986; **2**: 89-94.

McClure FJ. The destructive action, in vivo, of dilute acids and acid drinks and beverages on the rat's molar teeth. Journal of Nutrition 1943; **26:** 251-259.

McDonald JL and Stookey GK. Laboratory studies concerning the effect of acid-containing beverages on enamel dissolution and experimental dental caries. Journal of Dental Research 1973; **52:**211-216.

Meurman JH, Drysdale T and Frank RM. Experimental erosion of dentine. Scandinavian Journal of Dental Research 1991; **99:** 457-462.

Meurman JH and Frank RM. Progression and surface ultra-structure of in vitro caused erosive lesions in human and bovine enamel. Caries Research 1991a; **25:** 81-87.

Meurman JH and Frank RM. Scanning electron microscopic study of the effect of salivary pellicle on enamel erosion. Caries Research 1991b; **25:** 1-6.

Meurman, JH, Harkonen M, Naveri H, Koskinen, J, Torkko H., Rytomaa I, Jarvinen V and Turunen R. Experimental sports drinks with minimal dental erosion effect. Scandinavia Journal of Dental Research 1990; **98:** 120-128.

Meurman JH and ten Cate JM. Pathogenesis and modifying factors of dental erosion. European Journal of Oral Science 1996; **104:** 199-206.

Michalek SM and McGhee JR. Oral streptococci with emphasis on steptococcus mutans. In: McGhee JR, Michalek SM, Cassell GH. Oral microbiology. Harper & Row publisher, Philadelphia 1982, 679-690.

Miller WD. Experiments and observations on the wasting of tooth tissue erroneously designated as erosion, abrasion, denudation. Dental Cosmos 1907; **49**: 109-124.

Millward A, Shaw L and Smith A. Dental erosion in four-year-old children from differing socioeconomic backgrounds. Journal of Dentistry for Children 1994 a; **61**: 263-266.

Millward A, Shaw L, Smith AJ, Rippin JW and Harrington E. The distribution and severity of tooth wear and the relationship between erosion and dietary constituents in a group of children. International Journal of Paediatric Dentistry 1994 b; **4**: 151-157.

Millward A, Shaw L and Smith AJ. In vitro techniques for erosive lesion formation and examination in dental enamel. Journal of Oral Rehabilitation 1995; **22:** 37-42.

Milosevic A, Young, PJ and Lennon MA. The prevalence of tooth wear in 14-year-old school children in Liverpool. Community Dental Health 1994; **11**: 83-86.

Ministry of Health. Kingdom of Saudi Arabia, Annual Health Report 1996.

Mistry M and Grenby TH. Erosion by soft drinks of rat molar teeth assessed by digital image analysis. Caries Research 1993; **27**: 21-25.

Murray JJ, Rugg Gunn AJ, Jenkins GN. Fluoride tooth pastes and dental caries. In: Fluorides in caries prevention 1991; **9:** 127-160.

Nunn J. Prevalence of dental erosion and their implications for oral health. European Journal of Oral Science 1996; **104:** 156-161.

Nunn J, Shaw L and Smith A. Tooth wear - dental erosion. British Dental Journal 1996; **180**: 349-352.

O'Brien M. Children's Dental Health in the United Kingdom 1993. Office of Population Censuses and Surveys. HMSO 1994, London.

Oilo G, Dahl BL, Hatle G, and Gad A. An index for evaluating wear of teeth. Acta Odontologica of Scandinavica 1987; **45:** 361-365.

O'Sullivan E and Curzon M. Drug treatments for asthma may cause erosive tooth damage. British Medical Journal 1998; **317**: 820.

Petersen PE. Society and oral health. In: Community Oral Health Ed by Pine C 1997; **3:** 20-38.

Petersen PE and Gormsen C. Oral conditions among German battery factory workers. Community Dentistry and Oral Epidemiology 1991; **19**: 104 -106.

Pindborg JJ. Pathology of the dental hard tissues. Copenhagen: Munskgaard, 1970: 312-321.

Pitts NB, Evans DJ and Pine C. British association for the study of community dentistry (BASCD) diagnostic criteria for caries prevalence surveys-1996/1997. Community Dental Health 1977; **14 (Suppl)**: 6-9.

Restarski JS, Gortner RA and McCay CM. A method for measuring the effects of acid beverages on the teeth of small laboratory animals. Science 1945; **102:** 404 -405.

Reuter JE. Unusual dental incisal erosion. British Dental Journal 1978; **145**: 274.

Robb ND, Cruwys E and Smith BGN. Regurgitation erosion as a possible cause of tooth wear in ancient British populations. Archives of Oral Biology 1991; **36:**595-602.

Robb ND, Smith BGN, and Geidrys-Leeper E. The distribution of erosion in the dentitions of patients with eating disorders. British Dental Journal 1995; **178**: 171-175.

Rugg-Gunn AJ. Recent changes in the British diet. Journal of Paediatric Dentistry 1986; **2**:53 -59.

Rugg-Gunn A. Dietary aspects of tooth erosion. In: Nutrition and Dental Health. Oxford University Press, 1993; 11: 290 - 303.

Ryge G, Snyder M. Evaluating the clinical quality of restorations. Journal of American Dental Association 1973; **87:** 369-378.

Rytomaa I, Meurman JH, Franssila S and Torkko H. Oral hygiene products may cause dental erosion. Proceedings of the Finnish Dental Society 1989; **85**, 161-166.

Rytomaa I, Meurman JH, Koskinen J, Laakso T, Gharazi L and Turnuer R. In vitro erosion of bovine enamel caused by acidic drinks and other foodstuffs. Scandinavian Journal of Dental Research 1988; **96**: 324 -333.

Salako NO and Al-Bagieh NH. In vitro pH changes and acidic profile obtained during metabolism of dates by oral flora. Saudi Dental Journal 1994; **6**:21-26.

Savad EN. Enamel erosion multiple cases with a common cause? Journal New Jersey Dental Association 1982; **53**, 32-37.

Schulze UM, Pettke-Rank CV, Kreienkamp M, Hamm H, Brocker EB, Wewetzer C, Trott GE, Warnke A. Dermatologic findings in anorexia and bulimia nervosa of childhood and adolescence. Pediatric Dermatology 1999; **16**: 90 - 94.

Shaw L. Uncovering the epidemic? Symposium highlights. Reducing dental erosion in Britain's children (British Dental Association National Dental Conference)1998;24 :3-4.

Shaw L and Smith A. Erosion in children: an increasing clinical problem. Dental Update 1994; **21**: 103-106.

Silverstone LM, Saxton CA, Dogon IL and Fejerskov O. Variation in the pattern of acid etching of human dental enamel examined by scanning electron microscopy. Caries Research 1975; **9**:373 -387.

Smith BGN. Tooth wear: aetiology and diagnosis. Dental Update 1989; **16**: 204 -212.

Smith BGN and Knight JK. An index for measuring the wear of teeth. British Dental Journal 1984 a; **156**: 435-438.

Smith BGN and Knight JK. A comparison of patterns of tooth wear with aetiological factors. British Dental Journal 1984 b; **157**: 16-19.

Smith AJ, Millward A, Perry H, Bygrave AC and Granger JC. Erosion of incisors in cattle on self-fed silage with enzyme additive. Veterinary Record 1992; **130**: 352-353.

Smith BGN and Robb ND. The prevalence of tooth wear in 1007 dental patients. Journal of Oral Rehabilitation 1996; **23:** 232-239.

Smith AJ and Shaw L. Baby fruit juices and tooth erosion. British Dental Journal 1987; **162**: 65-67.

Sognnaes R, Wolcott R, Xhonga F. Dental erosion 1. Erosion-like patterns occurring in association with other dental conditions. Journal of American Dental Association 1972; **84:** 571-576.

Sorvari R. Effects of various sport drink modifications on dental erosion in rats with controlled eating and drinking pattern. Proceedings of the Finnish Dental Society 1989; **85**: 13-20.

Sorvari R, Meurman JH, Alakuijala P, and Frank RM. Effect of fluoride varnish and solution on enamel erosion in vitro. Caries Research 1994; **28**: 227-232.

Sorvari R, Pelttari A and Meurman JH. Surface ultrastructure of rat molar teeth after experimentally induced erosion and attrition. Caries Research 1996; **30:**163-168.

Spencer IJ and Ellis LN. The effect of fluoride and grapefruit juice on the etching of teeth. Journal Nutrition 1950; **42:** 107-115.

Stabholz A, Raistein J, Markitziu A, Galon H, Giter R, Gorenstein E, Srougi I, Bohrer J and Gedalia, I. Tooth enamel dissolution from erosion or etching and subsequent caries devlopment. Journal of Pedodontics 1983; **7:** 100-108.

Stafne EC and Lovestedt SA. Dissolution of tooth substance by lemon juice, acid beverages and acids from other sources. Journal of American Dental Association 1947; **34**: 586-592.

Stege P, Visco-Dangler L and Rye L. Anorexia nervosa: review including oral and dental manifestations. Journal of the American Dental Association 1982; **104**: 648-652.

Stephan RM. Effects of different types of human foods on dental health in experimental animals. Journal of Dental Research 1966; **45**: 1551-1561.

Sullivan RE and Kramer WS. Iatrogenic erosion of teeth. Journal Dent Child 1983; **50**: 192-196.

Tahir P and Maktabi A. Caries experience of 5-year-old children in Alkharj, Saudi Arabia. International Journal of Pediatric Dentistry 1997; **7:** 43-44.

Teo C, Young WG, Daley TJ, Sauer H. Prior fluoridation in childhood affects dental caries and tooth wear in a South East Queensland population. Australian Dental Journal 1997;**42:** 92-102.

Thomas AK. Further observations on the influence of citrus fruit juices on human teeth. New York State Dental Journal 1957; **23**: 424-430.

Todd JE. Children's dental health in England and Wales 1973. London: HMSO 1975.

Todd JE and Dodd T. Children's dental health in the United Kingdom in 1983. London: HMSO 1985.

Tuominen M and Tuominen R. Dental erosion and associated factors among factory workers exposed to inorganic acid fumes. Proceedings of the Finnish Dental Society 1991; **87**: 359-364.

Tuominen M and Tuominen R. Tooth surface loss and associated factors among factory workers in Finland and Tanzania. Community Dental Health 1992; **9**:143-150.

Watson IB and Tulloch EN. Clinical assessment of cases of tooth surface loss. British Dental Journal 1985;**159**: 144-148.

West ES and Judy FR. Destruction of tooth enamel by acidified candies. Journal of Dental Research 1938;**17**: 499-504.

West NX, Maxwell A, Hughes JA, Parker DM, Newcombe RG, Addy MA. Method to measure clinical erosion: the effect of orange juice consumption on erosion of enamel. Journal of Dentistry 1998; **26:** 329-335.

White DK, Hayes RC, and Benjamin RN. Loss of tooth structure associated with chronic regurgitation and vomiting. Journal of the American Dental Association 1978; 833-835.

Winter GB, Hamilton MC, James PMC. Role of the comforter as an aetiological factor in rampant caries of the deciduous dentition. Archives of Diseases in Childhood 1966; **41:** 207-212.

Winter GB, Rule DC, Mailer GP. The prevalence of dental caries in pre-school children aged 1 to 4 years. Part 1- Etiological factors. British Dental Journal 1971; **130**: 271-277.

Wyne AH, Adenubi J, Shalan T and Khan N. Feeding and socioeconomic characteristics of nursing caries children in a Saudi population. Pediatric Dentistry 1995; **17**: 451-453.

Wyne AH, Darwish S, Adenubi J. Caries prevalence and pattern in Saudi preschoolers. Journal Dental Research 1996; **75**:360 (abstract no 2739).

Wyne AH and Khan N. Use of sweet snacks, soft drinks and fruit juices, tooth brushing and first dental visit in high DMFT 4-6 year olds of Riyadh region. Indian Journal Dental Research 1995; **6:** 21-24.

Xhonga F and Valdmanis S. Geographic comparisons of the incidence of dental erosion: a two center study. Journal of Oral Rehabilitation 1983;**10:** 269-277.

Zero DT, Rahbek I, Proskin HM and Featherstone JDB. Comparison of the iodide permeability test, the surface microhardness test and mineral dissolution of bovine enamel following acid challenge. Caries Research 1990; **24:**181-188.

Zero DT. Etiology of dental erosion-extrinsic factors. European Journal Oral Science 1996; **104:**162-177.

Appendix 1
Copy of Dental Chart Used at Clinical Examination

STUDY OF ORAL HEALTH IN NURSERY SCHOOL CHILDREN IN JEDDAH

Study Number: .....

Name:..... Date of Birth:.....

School attended:.....

CARIES

	E	D	C	B	A	A	B	C	D	E
Mesial										
Lab/Buc										
Distal										
Pal										
Occlusal										
Mesial										
Lab/Buc										
Distal										
Pal										
Occlusal										
	E	D	C	B	A	A	B	C	D	E

Surface Score:

0 Present and Sound
1 Arrested dentinal caries
2 Caries (Restorable)
3 Caries (requiring Ext or RCT)
4 Filled and Decayed
5 Filled and Sound
6 Missing due to caries
8 Unerupted
$ Sealant restoration

RAMPANT CARIES: Yes/No

EROSION:

	B	A	A	B
Labial				
Palatal				

Scores: 0 No evidence of tooth wear
1 Tooth wear into enamel
2 Tooth wear into dentine
3 Tooth wear into pulp
9 Can't be assessed

APPENDIX 2

COPY OF THE QUESTIONNAIRE AND ACCOMPANYING LETTER

STUDY OF ORAL HEALTH IN NURSERY SCHOOL CHILDREN IN JEDDAH

We are currently carrying out a survey of oral health in children in nursery schools in Jeddah, and are seeking the help of you and your child for this purpose. Helping us will involve my looking at your child's teeth at school and taking two photographs (not x-ray) of his/her front teeth.

In our survey we want to find out more about the reasons why some children suffer from poor dental health. For this reason I am also asking you to complete and return the enclosed questionnaire, completing it will take no more than a few minutes. Any information you give us will be regarded as confidential and will be used for statistical purposes only. If you are unable to answer all the questions, please leave these blank, complete those you can and return the questionnaire to the school. If you are uncertain or would like further information, please feel free to contact me on:

Thank you so much for your help in our survey.

Dr. Manal Al-Malik

Postgraduate Researcher

STUDY OF ORAL HEALTH IN NURSERY SCHOOL CHILDREN IN JEDDAH

Study number: .....
Child's name: ..... Date of birth: .../..../199

Please tick or circle the appropriate answer to each question.

1) First, when your child was a baby was he/she breast or bottle fed?

Please tick

☐ Breast fed
☐ Bottle fed
☐ Both

If breast fed, for how long?

.....weeks
.....months
☐ still breast fed

2) When he/she was a baby, did your child have drinks other than milk in the bottle?

Please circle

Yes / No

a) If yes, what were these drinks?

Please tick

☐ Pure fruit juice e.g orange, lemon, apple
☐ Diluted fruit syrup e.g Suntop,Vimto,Sunquick
☐ Packed fruit juice
☐ Herbal drink
☐ Tea (with sugar /without sugar)
☐ Water (with sugar /without sugar)
Others please specify .....

b) How often did your child have them?

Please tick

☐ 1× day
☐ 2× day
☐ >2 × day
☐ <than all the above

c) When did your child stop having drinks (other than milk or plain water) from a bottle?

Please tick

☐ <6 months
☐ 6-12 months
☐ 12-18 months
☐ 18 months-2 years
☐ >2 years
☐ Still having drinks from a bottle

d) Did your child have drinks from a bottle at bedtime or naptime, or during the night?

Please tick

☐ Yes regularly
☐ Yes occasionally
☐ No never

e) What did he/she usually have at this time?

Please tick

☐ Pure fruit juice e.g orange, lemon, apple
☐ Packed fruit juice
☐ Diluted fruit syrup e.g Suntop, Sunquick, Vimto
☐ Herbal drink
☐ Tea (with sugar /without sugar)
☐ Water (with sugar /without sugar)
☐ Chocolate drink
Others please specify .....

f) How old were he/she when they stopped having drinks in a bottle at night or nap time?

Please tick

☐ <6 months
☐ 6-12 months
☐ 12-18 months
☐ 18 months-2 year
☐ >2 years
☐ still having a drink in a bottle at night or naptime.

3) Did your child ever have a miniature feeder or a dummy dipped in jam/syrup or honey?

Please tick

☐ Miniature feeder
☐ Dummy dipped in syrup, jam or honey
☐ Neither of these

4) What about nowadays, Does your child now have a drink at night or naptime?

Please circle

Yes / No

If yes, what is it that he/she drinks?

Please tick

☐ Milk
☐ Pure fruit juice
☐ Packed fruit juice
☐ Diluted fruit syrup e.g Suntop, Sun quick, Vimto
☐ Herbal drink
☐ Tea (with sugar /without sugar)
☐ Fizzy drinks e.g Cola/Pepsi, 7 UP, Miranda, etc
Others please specify .....

5) How often each day does your child usually have the following drinks:

Please tick a box for each item

	Never	Once/day	Twice/day	>2 time/day	1-2time/week
Pure fruit juice					
Fizzy drinks e.g Cola, Lemonade					
Diluted fruit Syrup					

6) Does your child usually have drinks from:

Please tick

☐ Feeder cup
☐ Cup with /without straw
☐ Infant feeding bottle
Others please specify.....

7) How often does your child eat the following fruits:

Please tick a box for each item

	Never	Once/day	Twice/day	>2 time/day	1-2time/week
Oranges					
Grapefruits					
Apples					
Dates					
Grapes					
Other fruits (please specify)					

8) Does your child have the following food items:

Please tick a box for each item

	Never	Once/day	Twice/day	>2 time/day	1-2time/week
Tomato ketchup					
Olives & Pickles					
Fruit yoghurt					
Mayonnaise					

9) Does your child regularly have: *Please circle*

Iron medicine Yes / No
Fizzy vitamin C tablets Yes / No

10) Are your child's teeth brushed regularly?

Please tick

☐ Yes once a day
☐ Yes twice a day
☐ Occasionally

11) Do you help or somebody else help your child to do it or does he/she brush his/her own teeth?

Please tick

☐ With help
☐ Brushes alone

12) When did you start brushing?

Please tick

☐ <6 months
☐ 6-12 months
☐ 12-18 months
☐ >18 months

13) Do you use for your child adult tooth paste or children tooth paste?

☐ Adults tooth paste
☐ Children's tooth paste
☐ What ever is available at home

14) What sort of tooth paste do you usually use for your child?

Please tick

☐ Crest	☐ Signal
☐ Oral-B	☐ Lion
☐ Colgate	☐ Sensodyne
☐ Maclean	☐ Any available

Others please specify.....

15) Has he/she ever had medical problems? *Please circle*
Yes / No

if yes, what were these? .....

16) Finally, Do you go out for work? *Please circle*
Yes / No

17) What sort of work do you do? .....

18) At what age did you finish your final education? .....

19) What about your husband, what sort of work does he do?
.....

20) At what age did he finish his education? .....

Thank you for your help.

APPENDIX 3

COPY OF THE QUESTIONNAIRE AND ACCOMPANYING LETTER

IN ARABIC

EASTMAN DENTAL INSTITUTE
for Oral Health Care Science

دراسة عن الرعاية الصحية للفم فى مدارس رياض الأطفال فى جدة

نحن نقوم حاليا بعمل دراسة عن الرعاية الصحية للفم فى مدارس رياض الأطفال بجدة . ونطلب المعاونة منكم ومن أطفالكم من أجل هذا الهدف . وذلك بالسماح لنا من فحص أسنان أطفالكم أثناء وجودهم فى المدرسة . وسوف تلتقط إثنتان من الصور الفوتوغرافية للأسنان الأمامية لكل طفل علما بأنه لن يظهر من وجه الطفل فى هذه الصورة سوى الفم فقط . ولن تؤخذ أى صورة أشعة .

فى دراستنا هذه نريد أن نتوصل للمزيد من أسباب سوء صحة الأسنان عند بعض الأطفال . ولهذا السبب أطلب من سيادتكم ملء الإستبيان وإعادته لنا . مع ملاحظة أن ملء هذا الإستبيان لن يستغرق إلا بعض من الدقائق . ونعدكم بكل صدق بأننا سوف نراعى السرية التامة عند إستخدامنا لأى معلومات تقومون مشكورين بكتابتها فى الإستبيان ونؤكد لكم بأنها سوف تستخدم لأغراض إحصائية فقط .

وإن كنتم غير قادرون على إجابة جميع الأسئلة الرجاء ترك المكان فارغ وإجابة ما تستطيعون الإجابة عليه ثم نرجو إعادة الإستبيان للمدرسة .

إذا كنتم فى حاجة للمزيد من المعلومات الرجاء الأتصال على الأرقام التالية :-

تليفون :-

الجوال :-

لكم جزيل الشكر والإمتنان لمساعدتكم لنا فى هذه الدراسة

دكتورة / منـــال المالك
باحثة دراســـات علـــيا .

دراسة عن صحة الفم على أطفال مرحلة الحضانة (٢ – ٥ سنوات) في جدة

الرقـم : .....

تاريخ الميـلاد : / / ١٩٩م

إسم الطالـب / ..... المـــوافـــق : / / ١٤١هـ

الرجاء وضع إشارة صح أو دائرة حول الإجابة المناسبة عند كل سؤال .

١) أولاً ، عندما كان طفلك رضيعاً هل كانت الرضاعة طبيعية (من الثدي) أو الرضاعة صناعية (من القارورة) ؟

الرجاء وضع إشارة

☐ رضاعة طبيعية

☐ رضاعة صناعية

☐ الإثنين معاً

إذا كانت الرضاعة طبيعية ، اذكري المدة .

..... أســابيـع

..... أشـهـر

☐ ما زالت الرضاعة مستمرة من الثدي حتى الآن .

٢) عندما كان طفلك رضيعاً هل تم إعطاؤه أي مشروبات غير الحليب في القارورة (الرضّاعة) ؟

الرجاء وضع إشارة

☐ نعم ☐ لا

أ) إذا كان الجواب نعم ، الرجاء توضيح نوع المشروبات :

☐ عصير فواكه طبيعية طازجة مثل البرتقال – الليمون – التفاح .

☐ عصير فواكة طبيعية معلبة .

☐ محلول شراب الفواكه المركز ، مثل سن توب – فيمتو – سن كويك .

☐ شاي الأعشـاب

☐ شاي (بسكر / بدون سكر)

☐ مـاء (بسكر / بدون سكر)

مشروبات أخرى الرجاء ذكرها : .....

ب) ما مدى تكرار تناول الطفل لها ؟

الرجاء وضع إشارة

- ☐ مرة واحدة في اليوم
- ☐ مرتين في اليوم
- ☐ أكثر من مرتين في اليوم
- ☐ أقل مما ذكر أعلاه

ج) متى توقف طفلك عن تناول مشروبات (غير الماء أو الحليب) من القارورة (الرضّاعة) ؟

الرجاء وضع إشارة

- ☐ أقل من ٦ أشهر
- ☐ ٦ - ١٢ شهراً
- ☐ ١٢-١٨ شهراً
- ☐ ١٨ شهراً - سنتين
- ☐ أكثر من سنتين
- ☐ ما زال يتناول المشروبات من القارورة (الرضّاعة)

د) هل تناول طفلك مشروبات من القارورة (الرضّاعة) عند النوم أو عند القيلولة أو أثناء الليل ؟

الرجاء وضع إشارة

- ☐ نعم دائماً
- ☐ نعم بعض الأحيان
- ☐ لا أبداً

هـ) ماذا كان يتناول عادة في تلك الأوقات ؟

الرجاء وضع إشارة

- ☐ عصير فواكه طبيعية طازجة مثل البرتقال - الليمون - التفاح
- ☐ عصير فواكه طبيعية معلبة
- ☐ محلول شراب الفواكه المركزة مثل سن توب - سن كويك - فيمتو
- ☐ شاى الأعشاب

☐ شاى (بسكر / بدون سكر)
☐ مـاء (بسكر / بدون سكر)
☐ حليب الشوكولاته
☐ أنواع أخرى الرجاء ذكرها .....

و) كم كان عمر طفلك عندما توقف من إستعمال القارورة (الرضَّاعة) عند القيلولة أو أثناء الليل ؟

الرجاء وضع إشارة

☐ أقل من ٦ أشهر
☐ ٦ - ١٢ شهراً
☐ ١٢ - ١٨ شهراً
☐ ١٨ شهراً - سنتين
☐ أكثر من سنتين
☐ مازال يتناول القارورة (الرضَّاعة) عند القيلولة أو أثناء الليل .

٣) هل تناول طفلك قط القارورة (الرضَّاعة) ذات المقـاس الصغـير أو مصاصـة (لهّايـة) مغموسـة في عسـل النحل أو مربى الفواكه أو أي محلول سكري آخر ؟

الرجاء وضع إشارة

☐ قارورة (الرضَّاعة) ذات المقاس الصغير
☐ لـهَّاية (مصاصة) مغموسة في عسل النحل أو مربى الفواكه أو أي محلول سكري آخر
☐ لم يتناول أيـاً منها

٤) في الفترة الحالية ، هل يتناول طفلك أي مشروبات عند القيلولة أو أثناء الليل ؟

الرجاء وضع إشارة

☐ نعم ☐ لا

إذا كان الجواب نعم ، ما هي هذه المشروبات ؟

الرجاء وضع إشارة

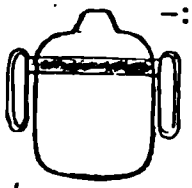
- ☐ حليب
- ☐ عصير فواكه طازجة
- ☐ عصير فواكه معلبة
- ☐ محلول شراب الفواكه المركز - مثل سن توب - سن كويك - فيمتو
- ☐ شاي الأعشاب
- ☐ شاي (بسكر / بدون سكر)
- ☐ مشروبات غازية مثل كولا ، بيبسي - سفن أب - ميرندا أو غيرها
- ☐ أنواع أخرى الرجاء ذكرها .....

٥) ما مدى تكرار تناول طفلك للمشروبات التالية يومياً ؟

الرجاء وضع إشارة في المكان المناسب عند كل نوع

	لا يتناول	مرة واحدة في اليوم	مرتين في اليوم	أكثر من مرتين في اليوم
١- عصير فواكه طازجة أو معلبة				
٢- المشروبات الغازية مثل كولا سفن أب ،ميرندا وغيرها				
٣- محلول شراب الفواكه المركز				

٦) هل طفلك عادة يشرب من :-



الرجاء وضع إشارة

- ☐ الكوب المـاص
- ☐ كوب عادي بإستخدام الشافط / من غير شافط
- ☐ أشياء أخرى الرجاء ذكرها .....

٧) ما مدى تكرار تناول طفلك للفواكه التالية :

الرجاء وضع إشارة عند كل عنصر

	لا يتناول	مرة واحدة في اليوم	مرتين في اليوم	أكثر من مرتين في اليوم
برتقال				
جريبفروت				
تفاح				
عنب				
فواكه اخري الرجاء ذكرها				

٨) هل تناول طفلك المواد الغذائية التالية :-

الرجاء وضع إشارة عند كل نوع

	لا يتناول	مرة واحدة في اليوم	مرتين في اليوم	أكثر من مرتين في اليوم
كاتشب				
المخللات والزيتون				
تمر ، رطب				
لبن زبادي بنكهة الفواكه				
مايونيز				

٩) هل يتناول طفلك بتكرار الأدوية التالية :-

الرجاء وضع إشارة

دواء الحديد ☐ نعم ☐ لا

فوّار فيتامين سي ☐ نعم ☐ لا

١٠) هل تنظفي أسنان طفلك بإنتظام ؟

الرجاء وضع إشارة

- ☐ نعم مـــرة في اليوم
- ☐ نعم مرتين في اليوم
- ☐ أحيـانـــاً

١١) هل تقومين شخصياً أو أي شخص آخر بمساعدة طفلك لتنظيف أسنانه بالفرشاة ؟

الرجاء وضع إشارة

- ☐ يفرش أسنانه بمساعدة
- ☐ يفرش أسنانه بنـفسـه

١٢) متى بدأتي بتنظيف أسنان طفلك بالفرشاة ؟

الرجاء وضع إشارة

- ☐ أقل من ٦ أشهر
- ☐ ٦ - ١٢ شهراً
- ☐ ١٢ - ١٨ شهراً
- ☐ أكثر من ١٨ شهراً

١٣) هل تقومين بإستعمال معجون الأسنان لطفلك الخاص بالأطفال أم الخاص بالكبار ؟

الرجاء وضع إشارة

- ☐ الخاص بالأطفال
- ☐ الخاص بالكبار
- ☐ أي معجون أسنان متواجد في البيت

١٤) ما نوع معجون الأسنان المستخدم عادة لطفلك ؟

الرجاء وضع إشارة

- ☐ كريست (Crest)
- ☐ أورال - بي (Oral - B)
- ☐ كولجيت (Colgate)

☐ ماكـلين (Maclean)

☐ سنسودين (Sensodyne)

☐ لـيـــون (Lion)

☐ نوع آخر الرجاء ذكره .....

١٥) هل عان أو يعاني طفلك من أي مرض صحي (غير الأسنان) ؟

الرجاء وضع إشارة

☐ نعم ☐ لا

إذا كان الجواب نعم ، الرجاء التوضيح .....

١٦) وأخيراً هل تخرجين للعمل خارج البيت ؟

الرجاء وضع إشارة

☐ نعم ☐ لا

١٧) ما نوع العمل الذي تقومين به ؟

.....

١٨) في أي سن أنهيت مرحلة الدراسة ؟

.....

١٩) ماذا عن زوجك ، ما نوع العمل الذي يقوم به ؟

.....

٢٠) في أي سن أنهى مرحلة الدراسة ؟

.....

شـكـــراً جـزيـلاً لمـســاعـدتِـك

APPENDIX 4

Letters seeking formal approval of the study to the 'Ministry of Higher Education' and reply received from the 'President General for Girls Education School' in Arabic

Eastman Dental Institute
for Oral Health Care Sciences
University of London

256 Gray's Inn Road, London, WC1X 8LD
Telephone: +44 (0)171 915 plus ext. or +44 (0)171 915 1000
Facsimile: +44 (0)171 915 1012
Website: www.eastman.ucl.ac.uk

National Centre for Transcultural Oral Health
Professor Raman Bedi DDS MSc BDS FDSRCS
Tel: 0171 915 2314/1193 Fax: 0171 915 1233

19 June 1998

Ministry of Higher Education
Saudi Arabia

Dear Sirs

Dr Manal Al-Malik

Dr Manal Al-Malik is a PhD postgraduate at the Eastman Dental Hospital carrying out research on erosion in pre-school children.

The survey will be carried out on Saudi pre-school children to determine the prevalence of erosion, caries and rampant caries in nursery school children in Jeddah. Dr Al-Malik will need to go to Saudi to examine 1,000 children in selected private and public schools.

Dr Al-Malik will be ready to leave in September 1998 to collect the data, and will need to stay in Saudi for at least three months.

Yours faithfully

Professor Raman Bedi
Head of Department

EASTMAN DENTAL INSTITUTE
for Oral Health Care Science

معهد إيستمان لطب الأسنان
لعلوم الرعاية الصحية للفم

256 طريق جارى وان – لندن WCIX8LID

المركز القومى الثقافى للرعاية الصحية للفم .

بروفوسير رامان بيدى EDSRCS - BDC - MSC - DDS

رئيس الشعبة

د . روث D هولت PhD , Mscm BChD

مدرس أول . 1193 / 1138 هاتف 0171915

بريد إلكترونى Rholt@eastman . ucl . ac . uk

٢٠ / فبراير / ١٩٩٧ م .

لمـــن يهمه الأمـــــــر

دراسة عن الرعاية الصحية للفم فى مدارس رياض الأطفال فى جدة :

هذا ليشهد أن الدكتورة / منال المالك ترغب فى القيام بدراسة للرعاية الصحية للفم فى مدارس رياض الأطفال بجدة .

إن هدف الدراسة هو الأستفسار والإستبيان عن مدى تأثير التسوس والتآكل فى أسنان الأطفال الصغار .

الدراسة تتضمن فحص أسنان بسيط للأطفال فى المدارس وإثنتان من الصور تلتقط للأسنان الأمامية لكل طفل علما بأنه لن يظهر من وجه الطفل سوى الفم فقط . ولن تؤخذ أى صور أشعة .

د . المالك مسجلة فى جامعة لندن للحصول على درجة عليا (دكتوراه) وهذه الدراسة تمثل الأساس لمشروع بحثها .

مدرس أول / روث د . هولت

المراقب

/١٠٩٣٧
/٢/٢٦

سعادة مدير عام تعليم البنات بمنطقة مكة المكرمة المحترم

السلام عليكم ورحمة الله وبركاته وبعد

نرفق لكم الطلب المقدم من المبتعثه إلى بريطانيا / منال ابراهيم المالك المتضمن التماسها السماح لها القيام مع بداية الفصل الدراسي الأول للعام الدراسي القادم بزياره ميدانيه لبعض مدارس رياض الاطفال الخاصه والحكوميه التابعه للرئاسة في منطقتكم وذلك لإجراء بحث عن تاكل اسنان الاطفال الناتجه عن أسباب غير تسوس الاسنان .

وحيث أن البحث جيد وبالامكان الاستفاده منه لذا نأمل مساعدتها وإطلاعنا بنتائج البحث ليمكن من الاستفاده منه في مجال توعيه الطالبات .

ولكم أطيب تحياتي ،،،،،،،،،

الوكيل للإعداد والتطوير التربوي بالنيابه

عبدالرحمن بن محمد الحرقان

AL - MOUSA

ص/مع التحيه لمكتب معالي الرئيس العام .ص/ مع التحيه لسعادة الوكيل الإعداد والتطوير التربوي .ص/للملف العام مع المسوده .ص/الملف القراءه .ص/المذكوره على الفاكس ٢/٦٥٣٠٣٦٨ .ص/مع صورة الاساس الإدارة الطبية .

بسم الله الرحمن الرحيم

المملكة العربية السعودية
الرئاسة العامة لتعليم البنات
الإدارة العامة لتعليم البنات بمنطقة مكة المكرمة
الإدارة العامة لتعليم البنات بمحافظة جدة
وحدة الدراسات والبحوث التربوية

عدد ٦/١/٤٠
تاريخ ١٤١٩/٥/٢١هـ
لفه
الموضوع

المكرمة مديرة المدرسة الروضه - الحمانه المحترمة

السلام عليكم ورحمة الله وبركاته وبعد:-

نفيدكم أن الطالبة / منال ابراهيم الجابر.... بصدد القيام بتطبيق ميداني لبحثها بعنوان (تكوين استبانة لاستطلاع آراء المعلمات) عليه نأمل التكرم بتسهيل مهمة الباحثة لتطبيق استبانتها. مع اسباب غير تصوير الاستبانة .

مع الشكر والتقدير،،، ،،،

مديرة ادارة الاشراف التربوي

د.طريفة الشويعر